the prairie beekeeping manual

Saskatchewan
Agriculture

Manitoba
Agriculture

Alberta
AGRICULTURE

87-00099/

Alberta residents may obtain a copy of this publication from:

Print Media Branch
Alberta Agriculture
7000 - 113 Street
Edmonton, Alberta, T6H 5T6
OR
Alberta Agriculture's district offices

Saskatchewan residents may obtain a copy of this publication from the:

Soils and Crops Branch
Saskatchewan Agriculture,
Box 3003
Prince Albert, Saskatchewan
S6V 6G1

Manitoba residents may obtain a copy of this publication from the:

Publication Distribution Centre,
Manitoba Agriculture,
411 York Ave.,
Winnipeg, Manitoba
R3C 3M1

RV 1986 07 3M

TABLE OF CONTENTS

Page

FOREWORD V

ACKNOWLEDGEMENTS V

I THE HONEY BEE 1

THE IMPORTANCE OF POLLINATION 1
HONEY BEE CLASSIFICATION 1
BIOLOGY OF THE HONEY BEE 2
— The colony 3
— Developmental stages of the honey bee 5
— The mated queen 5
— Workers 5
— Drones 7

FOOD REQUIREMENTS, COLLECTION & PROCESSING 7
— The bee-plant relationship 7
— Collecting nectar and pollen 7
— Food processing and storage 10
— Robbing honey from other colonies 11

II GETTING STARTED IN BEEKEEPING 11

WHAT IS BEEKEEPING? 11
THE STING 11
PURCHASING BEES 11
BASIC BEEKEEPING EQUIPMENT 11
EQUIPMENT NECESSARY TO OPERATE A 5-COLONY APIARY 14
THE COLONY EXAMINATION 15
EXPANDING THE OPERATION 15
THE BEE ACT 16

III NECTAR AND POLLEN PLANTS 16

IV SUPPLEMENTARY FEEDING 17

CARBOHYDRATE SUPPLEMENTS 18
— Types of feed 18
— Types of feeders 19

PROTEIN SUPPLEMENTS 21
— Pollen supplements and substitutes 21
— Supplement formulations 21
— Substitute formulations 22
— Pollen and disease transmission 22
— Harvesting and storing pollen 22

SUPPLYING WATER TO HONEY BEE COLONIES 23

V SPRING MANAGEMENT 23

SELECTING AN APIARY SITE 23
APIARY LAYOUT 24

(cont'd) **Page**

FIELD RECORDS 25
PACKAGE BEES 25
WINTERED COLONIES — EARLY SPRING 26
CHECKING COLONIES 28
FEEDING COLONIES 28
REQUEENING WINTERED COLONIES 28
EQUALIZING COLONY STRENGTH 28
UNITING COLONIES 29
DIVIDING COLONIES 29
MOVING TO SUMMER APIARY SITES 30
APIARY MAINTENANCE 31
SPACE REQUIREMENTS AND SUPERING 31
DRAWING FOUNDATION 32
USE OF QUEEN EXCLUDERS 33
TWO-QUEEN COLONIES 33
SWARMING 34
— Swarm prevention 34
— Swarm control 35
— Handling swarms 35

VI REMOVING HONEY FROM THE HIVE 36

WHEN TO REMOVE HONEY 36
ROBBING 37
REMOVING BEES FROM THE HONEY SUPERS 37
— Shaking and brushing 37
— Bee escape boards 37
— Fume or acid boards 38
BEE BLOWERS 39
LOADING AND MOVEMENT OF HONEY SUPERS 39

VII HONEY 39
COMPOSITION 39
VISCOSITY 40
MOISTURE CONTENT AND HYGROSCOPICITY 40
GRANULATION 40
REDUCING HONEY QUALITY 40
— Fermentation 41
— Heating and storage 41

VIII EXTRACTING THE HONEY 42

— Honey house types 42
— Space 42
— Cleanliness 42
— Location 43
— Insurance 43
COMPONENTS OF THE HONEY HOUSE 44
— The loading area 44
— The hot room 44
— The extracting room 44
— The tank room and filling room 45
— The storage area 45

VIII HONEY EXTRACTION 45

— Safety considerations 45

(cont'd) **Page**
— Pallets 45
— Uncapping devices 45
— Extractors 46
— The sump 47
— The honey pump 47
— Settling tanks 47
— Straining honey 48
— Packing honey 48
HANDLING BEESWAX CAPPINGS 48
— Draining 48
— Feeding cappings back to bees 48
— Centrifugal separation 48
— Wax press 49
— Cappings melter 49
— Spin-float separator 49
RENDERING BEESWAX CAPPINGS 49
— Processing cappings in water 49
— The steam chest 50
— The solar wax melter 50
RENDERING BROOD COMBS 51

IX MARKETING THE CROP 51

MARKETING HONEY 51
— Farm gate sales 51
— Retail store sales 51
MARKETING BEESWAX 52

X FALL AND WINTER MANAGEMENT 52

ROBBING 53
PACKAGE OPERATIONS 53
USING CALCIUM CYANIDE TO KILL COLONIES 53
WINTERING HONEY BEE COLONIES 54
— What to winter 54
— Feeding colonies for winter 54
OUTDOOR WINTERING 55
INDOOR WINTERING 56
— Ventilation principles of wintering buildings 56
— Design recommendations 58
— Hive arrangement 62
— Feeding colonies indoors 62

XI THE QUEEN 63

NATURAL REQUEENING 63
LAYING WORKERS 64
REQUEENING AS A MANAGEMENT TOOL 64
METHODS OF QUEEN INTRODUCTION 64
BANKING QUEENS 65
QUEEN CAGE CANDY 65

XI QUEEN REARING 65

— Using naturally-produced queen cells 65
— Breeder colonies 66
— Cell building colonies 66

(cont'd) **Page**
- — Rearing queens without grafting 66
- — Rearing queens by grafting 66
- — Queen mating colonies 67

XII HONEY BEE HEALTH 68

HONEY BEE BROOD DISEASES 68
- — American foulbrood 68
- — European foulbrood 70
- — Chalkbrood 71
- — Sacbrood 72

ADULT HONEY BEE DISEASES 73
- — Nosema disease 73
- — Bee paralysis 74

ANOMALIES IN COLONY CONDITION 74
- — Chilled brood 74
- — Gassed brood 74
- — Starvation 74
- — Dysentery 74

MITES 75
- — Varroa disease 75
- — Acarine disease 76
- — Other parasitic mites 76
- — External mites 76

INSECT PESTS OF HONEY BEE COLONIES 76
- — Ants 77
- — Wasps 77
- — Wax moths 77
- — The bee louse 77

UNWELCOME INTRUDERS 77
- — Mice 77
- — Skunks 77
- — Bears 77
- — The Africanized honey bee 78

PESTICIDE POISONING OF HONEY BEES 78
- — Toxicity of pesticides to honey bees 79
- — Symptoms of bee poisoning 79
- — Preventing losses 82
- — Documenting bee kills 82

APPENDICES 83
- — Glossary of apiculture terms 83
- — Additional references 91
- — Apiculture and related personnel 92
- — Canada Honey Regulations pertaining to grading honey 94
- — Recommendations for feeding antibiotics 97

FOREWORD

Canada is a leading honey producing country, ranking behind the Soviet Union, China, the U.S., Mexico and Argentina. Of Canada's 31.9 thousand tonnes production (1982), the three prairie provinces accounted for approximately 70 per cent or 22.2 tonnes. Alberta is the leading Canadian producing province, averaging 10 thousand tonnes annually or 30 per cent of Canada's production. Honey produced in the prairie provinces is light in color and mild in flavor, and hence it is highly regarded on the domestic and export markets for blending with darker honeys produced elsewhere.

The beekeeping conditions on the Canadian prairies are somewhat unique. Hot summers, large areas of cultivated nectar-producing crops, and a short but intense nectar flow result in yields averaging up to 90 kg (200 lb) per hive. On the other hand long severe winters present unique problems in the overwintering of bees.

There is a wealth of literature concerned with the biology and management of the honey bee. However, most of this has been directed to beekeeping conditions in the U.S. and Europe. This manual has been prepared to assist beekeepers in the management of honey bees under prairie conditions. It should be viewed as a supplement to the references presented in Appendix 1 and other extension literature.

ACKNOWLEDGEMENTS

Permission to reproduce diagrams, tables and photos is gratefully acknowledged to the following: International Bee Research Association; Dadant and Sons Inc.; Manitoba Department of Agriculture; Academic Press; Dr. M. V. Smith, University of Guelph; Dr. D. Nelson, Agriculture Canada. Donald Dixon and Barry Fingler of the Manitoba Department of Agriculture contributed to the sections on indoor wintering, selecting and the layout of apiary sites, the queen, and pesticide damage. Dr. Cam Jay of the University of Manitoba contributed to the section on "What is Beekeeping".

I. THE HONEY BEE

THE IMPORTANCE OF POLLINATION

Many plant products which we consume depend on or benefit from pollination. As well, many insect-pollinated plants form part or all of the diet of many animals raised for milk and meat production. Insect-pollinated legumes have the added role of soil enrichment through their nitrogen-fixing capacity. Inadequate pollination leads to reduced crop yields, delayed fruit and seed set and a high percentage of inferior fruit. Insect-pollinated ornamentals, both cultivated and uncultivated, brighten the landscape, provide shelter and food for wildlife, and aid in soil stabilization.

Bees are thought to be the most efficient of the insect pollinators. In many areas of the world the populations of native bees have suffered as a result of changing agricultural practices, widespread land clearing and consequent elimination of nesting sites, and the use of pesticides. The honey bee remains as one of the few pollinating insects which can be cultivated, managed and moved in great numbers into a crop requiring pollination. Thus the value of the honey bee to our economy is far greater than merely that of the honey and beeswax produced. For agricultural crops alone this value has been estimated at anywhere from ten to one hundred times the monetary value of honey and beeswax, and this figure does not include the aesthetic value of cultivated and wild ornamentals nor their value to wildlife.

HONEY BEE CLASSIFICATION

Honey bees are members of the class Insecta, which includes all insects such as dragonflies, leafhoppers, butterflies, beetles, mosquitoes and wasps. Insects are in turn part of a larger group, the Arthropoda (jointed legs), which includes four other classes: the Arachnida (spiders, ticks, scorpions, and mites) the Chilopoda (centipedes), the Diplopoda (millipedes), and the Crustacea (lobsters, shrimp, barnacles, and crayfish). Members of the class Insecta are characterized by having a protective exoskeleton or outer shell, three pairs of legs, one or two pairs of wings, one pair of antennae and a segmented body divided into head, thorax and abdomen.

Within the Insecta there are smaller groupings or orders, and honey bees are in the order Hymenoptera ("membrane-wing"). This order also includes sawflies, parasitic wasps, ants, wasps and other bees. There are about 20,000 species of bees in the world: about 3,300 of these are native to North America. Bees have the following characteristics: a long, well-shaped tongue, branched (plumose) body hairs, males with 13 antennal segments and seven visible abdominal segments, females with 12 antennal segments and six visible abdominal segments, females with a pollen-collecting apparatus on the underside of the abdomen or on the hind legs, and females with a sting. Most of the bees are solitary but some live communally and some, such as the bumble and honey bees, have developed a truly social life style. Bumble bees and honey bees are in the family Apidae: the scientific name of the western honey bee is *Apis mellifera* (L.), meaning "honey-bearing bee". Thus beekeeping has been named "apiculture", or the culture of *Apis*. There are three other species of *Apis* species recognized at present, all native to Asia. *Apis florea*, the little honey bee, and *Apis dorsata*, the giant honey bee or rock bee, build single comb dwellings in sheltered but open areas. They do not live in closed cavities as do *A. cerana indica*, the Indian honey bee, and *A. mellifera*. The comb of *A. florea* may measure 40 cm in length and 20 cm in depth while that of *A. dorsata* may be up to two metres in length, a metre in depth and 20 cm in width. *A. cerana indica* builds multiple comb dwellings and is similar in many respects to *A. mellifera*, though smaller in size.

There are several geographic races of *Apis mellifera* in Europe. These races have developed in isolation from one another and have evolved characteristics which suit them to their particular environments. None of these races is native to the Americas, but all have been introduced at one time or another. The Italian bee, *Apis mellifera ligustica*, is known for its golden color, its gentleness, and its tendency towards prolific brood-rearing and populous colonies throughout the season. Because of this tendency its food consumption is high throughout the year, including the winter. The Caucasian bee, *A.m. caucasica*, is a darker-colored bee, quite gentle, with a somewhat slower buildup in numbers, strong colonies, and a strong tendency to propolize. The Carniolan bee, *A.m. carnica*, is also dark-colored, quiet and gentle, with its brood production closely related to the availability of pollen; it characteristically overwinters in small colonies and with less food consumption. The dark bee, *A.m. mellifera*, is very dark in color, with a tendency to be nervous and aggressive; it has a slow spring buildup.

Other races of *A. mellifera* include those which originate in Africa, the most famous (or infamous) of which is the African bee, *Apis mellifera scutellata*. Traits of this race are extreme aggression, small colonies, lack of clustering ability (since this race does not need to winter), and a tendency towards both migratory and reproductive swarming behaviour.

BIOLOGY OF THE HONEY BEE

Before taking up beekeeping as either a hobby or a full-time occupation some knowledge of honey bee biology is necessary. It is through knowledge of the natural instincts of the honey bee colony and adaptation of management techniques to specific situations that maximum honey production is attained.

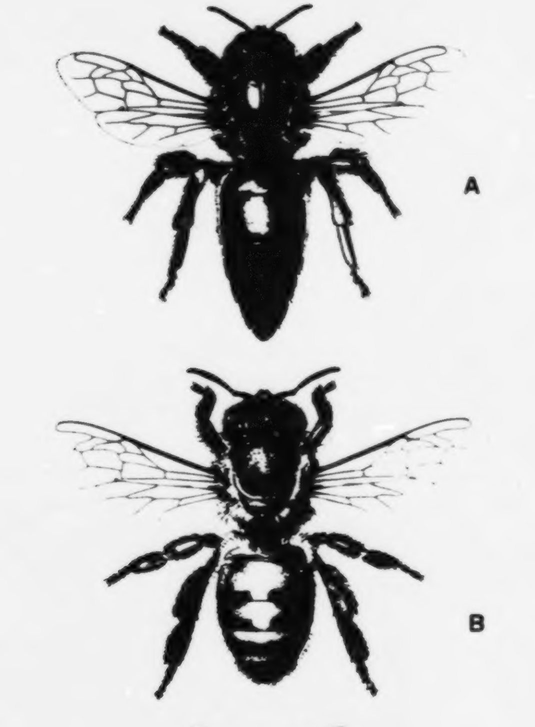


FIGURE 1.
The three castes of the honey bee. A Queen. B Worker. C Drone. (Taken from Dade, 1977).

The colony — The honey bee colony is a family consisting of a single mother, the queen; many daughters, the workers; and a varying number of sons, the drones. The three castes, queen, worker, and drone differ in size and shape (figures 1 and 2) and are each specialized to perform certain tasks within the colony. This specialization and consequent interdependence of the castes makes the honey bee colony a truly social unit. The colony can be considered an individual organism consisting of from 10,000 to 60,000 cells, none of which can exist for very long away from the others. The organism perpetuates itself through successive cycles of brood-rearing. Reproduction of the organism, the colony, occurs through swarming.

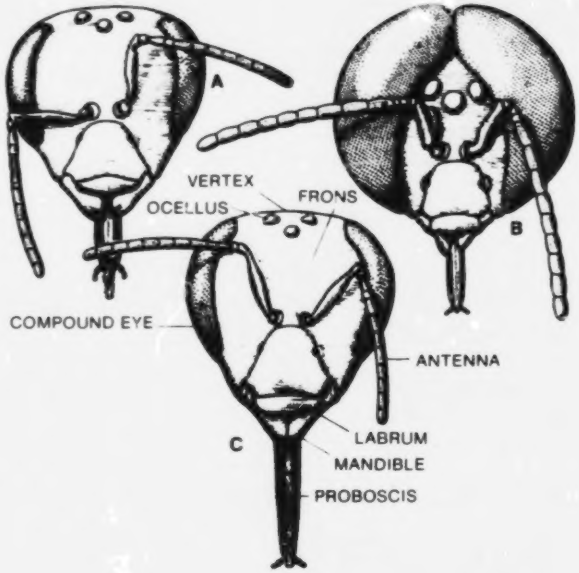


FIGURE 2.
Heads of three castes of honey bee. A: Queen. B: Drone. C: Worker. (Modified from Dade, 1977).

The colony nests in a dark enclosed cavity, such as a hollow tree or within the wall of a building, which provides protection from predators and inclement weather conditions and allows regulation of the temperature and humidity of the nest. Wax combs are built by the young worker bees to form the substrate of the nest; these combs are attached to the top of the cavity, are perpendicular and are built more or less parallel with a bee space of about 8 mm between. They are made up of six-sided (hexagonal) cells extending out and angled slightly upwards from both sides of the midrib. The cells are used for brood-rearing and food storage. Brood is reared in the centre of the nest in a hemisphere or sphere; pollen is stored above and to the sides of the brood and honey is stored above and to the sides of the pollen. We refer to the physical dwelling place of the bee as the hive, while the bees themselves form the colony.

Most of the combs are made up of worker-sized cells, but some drone comb will be built along the bottoms and sides of combs (figure 3). Queens are raised in specialized queen cells, which begin as queen cups and when drawn out and capped hang in a vertical position on the face of the comb (figure 4).

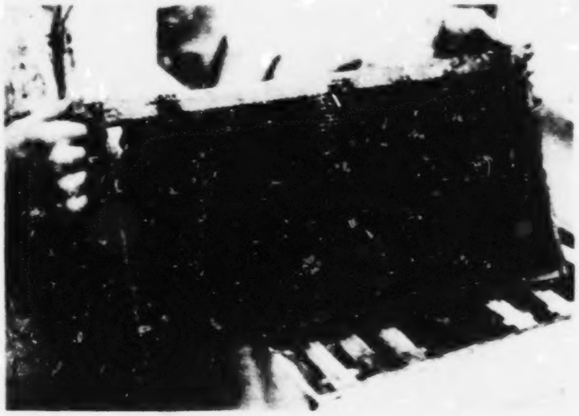


FIGURE 3.
Frame with small worker sized cells in centre and larger drone sized cells along top and end bars.

The races of bees used in Canadian beekeeping are adapted to a temperate climate and the cycle of colony development follows the cycle of the seasons. Whereas other species of social bees, such as bumble bees, survive the winter by having only the new queens hibernate, honey bees maintain perennial colonies with at least two of the three castes surviving from fall through to spring. European honey bee races have evolved the inclination to store food, when available, far in excess of day-to-day demands in order to survive periods of dearth and inclement weather. Their ability to control the temperature of the brood nest by air circulation and evaporation of water when too hot and by clustering together and generating heat energy when too cold allows colonies to survive in nearly every environment inhabited by the human race.

In spring an overwintered colony of bees may consist of from 10,000 to 20,000 individuals or more. With the onset of the spring pollen and nectar flows the colony begins to increase in numbers, providing there is access to food and water. A shortage of honey, pollen or water will lead to a temporary reduction or cessation of brood-rearing. As the number of bees increases and there are more bees to maintain the brood nest, the size of the brood nest increases, and the colony expands in an upward direction, taking advantage of the heat rising from the brood nest. Headed by a queen with optimum laying capacity and no limits on food and space, colony numbers increase to a maximum of approximately 60,000 comprised of a single queen, a few thousand drones and many workers.

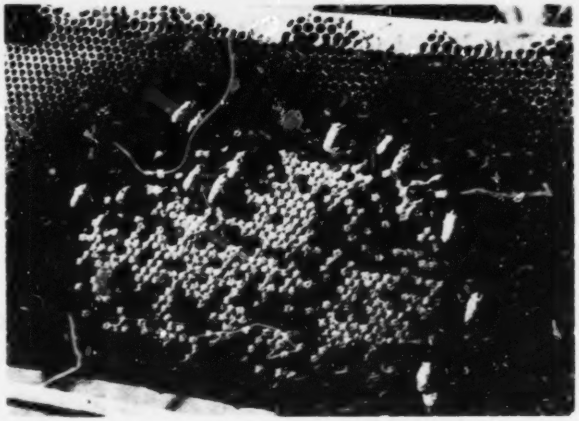


FIGURE 4.
Queen cells.

In the late spring and early summer, if conditions warrant, the colony may begin swarming preparations. Swarming is initiated when the amount of queen substance available to the worker population becomes too low to maintain colony cohesion. This lessening in production may occur through the queen becoming honey-bound and not laying many eggs, or through the fast development of a large worker population leading to less queen substance available per bee. New queens are produced in queen cells while the old queen's egg-laying rate falls off and her abdomen reduces in size. Her nurse bees tend to feed her less, agitate her and eventually force her out of the hive with a good portion of the workers and drones.

The swarm generally issues around midday when it is sunny and warm, often on a day following a period of inclement weather, during which the whole of the population has been crowded into the hive. The swarm generally settles on a branch, a fence post or in some such location close to the hive and remains there while scout bees search for a new home, returning to communicate their findings by means of the same sort of bee dance used to recruit foragers. Eventually the swarm "decides" on one of these locations and moves there to take up housekeeping. In the meantime a virgin queen has emerged in the old hive. She also may leave the parent colony with a smaller number of workers, termed an afterswarm. Several such afterswarms may issue, or one of the virgin queens may search out and sting the other queens in their cells and, once mated, will then become the new mother of the parent colony.

The colony continues to build toward a peak population, and stores excess honey and pollen through the main summer nectar flow. Once the flow ceases and the summer draws to an end, the colony population decreases through the death of worker bees, a slowdown in egg-laying and brood-rearing, and expulsion of the remaining drones from the colony. The bees which do hatch will live for several months and will form the wintering population. As fall progresses egg-laying generally ceases, with a period of from one to three months when there is little or no brood-rearing.

TABLE 1: Length of Development Stages of the Honey Bee

	Workers		**Queens**		**Drones**	
Day	Stages	Moults	Stages	Moults	Stages	Moults
1	Egg		Egg		Egg	
2						
3						
4	1st larval	(hatching)	1st larval	(hatching)	1st larval	(hatching)
5	2nd larval	1st moult	2nd larval	1st moult	2nd larval	1st moult
6	3rd larval	2nd moult	3rd larval	2nd moult	3rd larval	2nd moult
7	4th larval	3rd moult	4th larval	3rd moult	4th larval	3rd moult
8	Gorging	4th moult	Gorging	4th moult (sealing)	Gorging	4th moult
9		(sealing)				
10	Pre-pupa		Pre-pupa			(sealing)
11			Pupa	5th moult	Pre-pupa	
12	Pupa	5th moult				
13						
14						
15					Pupa	5th moult
16			Adult	6th moult (emerging)		
17						
18						
19						
20						
21	Adult	6th moult (emerging)				
22						
23					Adult	6th moult
24						(emerging)

Modified from Bertholf, L. M. 1925. The moults of the honeybee. Journal of Economic Entomology 18(2):380-384, taken from (Laidlaw 1979).

As the temperature grows cooler the bees gather together; at about 14°C they form a well-defined cluster which then contracts as ambient temperatures grow colder. Although very little activity occurs in this winter cluster, the bees are not hibernating. Instead they are eating honey and generating heat through rapid muscle vibrations. Through the winter the cluster gradually shifts position in order to utilize all the honey stores. Temperatures of 6-7°C at the edge and 29°C in the centre of the cluster are maintained.

Some time in January or February the colony begins to rear brood again, and the temperature within the cluster is maintained at about 33°C. Brood-rearing causes the workers to age rapidly because of the stresses related to royal jelly production. Honey consumption within the hive increases from a maintenance level of 1.5-2 kg/month to 7-8 kg/month. By early spring colonies may be getting short of pollen and honey, depending on the severity of the winter and the rate of brood-rearing. The onset of spring temperatures and nectar and pollen flows allows renewal of food stores and the rapid expansion of the brood nest, and the cycle begins again.

Developmental stages of the honey bee — Each caste passes through the same developmental stages from egg to adult, though the total developmental time is different (table 1). Queens take about 16 days, workers about 21 and drones about 24 days to change from egg to adult. Using the worker bee as an example, once the egg has been laid in a cell, the embryo within the egg develops for three days and then hatches into the larva, which at this time is about 1.6 mm in length and is coiled in the end of the cell. Provisioned first with royal jelly produced by the young adult workers, and later with a mixture of modified jelly, honey and pollen, the worker larva feeds and grows over a period of five days. During this period it moults four times, until the eighth day it has increased its weight by 1500 times and fills the end of the cell. House bees cap over the cell on the eighth day and over the next three days the larva stretches out lengthwise in the cell and spins a silken cocoon in which to pupate. The larva then moults for the last time. The change in form from the grub-like larva to the adult bee occurs during the time the cell is capped over, referred to as the prepupal and pupal stages. About the 21st day the new adult worker begins to chew at the cappings imprisoning her in her cell, and finally emerges as a "baby bee", easy to recognize by her uncertain steps, light color and fuzzy appearance.

The mated queen — The mated queen is the central figure of the colony. It is she who lays the eggs that develop into workers, drones and queens. She also maintains colony cohesion through production of chemicals called pheromones. The primary pheromones, 9-oxodecenoic acid and 10-hydroxydecenoic acid (queen substances), are produced by the queen's mandibular glands. These queen substances are picked up by the nurse bees who attend the queen and are passed in the process of food exchange (trophallaxis) to every colony member, acting to suppress the inclination to swarm or supersede, as well as to suppress worker ovary development (see section 11). The queen has no part in caring for the brood, and it is the worker caste which feeds and cares for the brood and performs all of the household and field tasks.

Workers — Worker bees have many tasks to perform during their adult lives. The worker's life is divided into two main periods, the hive period (house bees) and the field period (field bees), each generally about three weeks in duration through the summer months. There is a general sequence of tasks performed with age and with the stage of physiological development, with much overlapping of tasks, omissions of tasks and "preferences" for certain tasks shown by individuals. Each bee performs many different duties through the day interspersed with frequent rest spells. Housekeeping duties of the worker bees include feeding the larvae, building new wax combs, capping brood and honey cells, processing nectar and pollen for storage, feeding the queen and drones, removing dead brood, adults and foreign material from the hive, and ventilating and defending the colony.

Newly-emerged workers engage in cell-cleaning activities, and begin feeding older larvae with pollen and nectar. From about the sixth to the twelfth day the hypopharyngeal glands in the heads of the worker bees produce royal jelly, a protein-rich food which they feed to young worker and drone larvae and to queens throughout the larval stage. The queen's retinue is also made up of these young workers, who continually care for her and feed her with royal jelly.

Comb-building is undertaken by workers once their wax glands have begun functioning, between the 12th and 18th day. The four pairs of wax glands are located under the plates or sternites of abdominal segments four through seven of the worker (figure 5), and secrete scales of wax 1-2 mm diameter into the pockets beneath the sternites. The workers engaged in comb-building hang quietly in festoons, manipulating the wax scales from abdominal pockets to mandibles, chewing and softening the wax, and depositing it on a comb where it is worked and smoothed over. Neither the

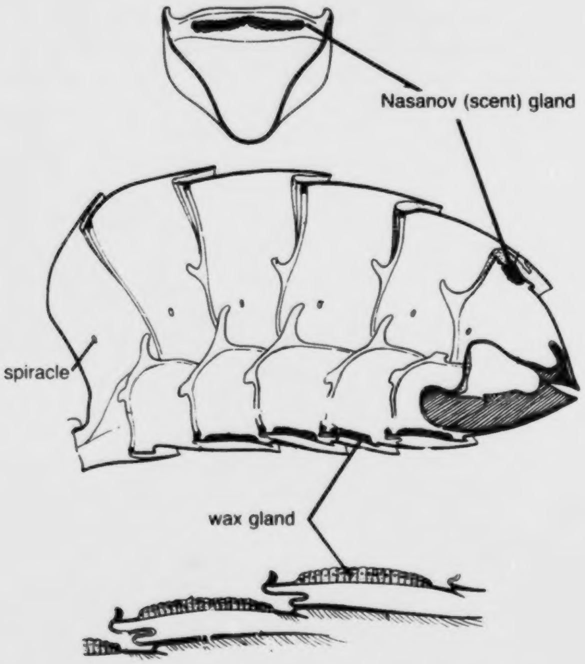


FIGURE 5.
The wax and Nasanov (scent) glands of the worker honey bee. (Modified from Snodgrass in The Hive and the Honey bee, 1975).

queen nor the drones develop wax or hypopharyngeal glands. When about a week old, worker bees begin short orientation or "play" flights. These often occur in the early afternoon of warm sunny days. Many young bees fill the air in front of the hive and hover there facing the hive, apparently memorizing the orientation of the hive and any landmarks which will aid in locating their home. After a short time the bees re-enter the hive and the excess activity ceases.

Older house bees may take on colony defense and temperature regulation duties when they are physiologically no longer able to feed young larvae or produce wax. Guard bees stand at the entrance to the hive and intercept strangers and insects of other types as they try to enter the hive. In times of honey flow any forager loaded with honey or pollen will be allowed in. When the colony has been disturbed by predators or during dearth periods, when strangers are likely to be robber bees, the guard bees are greater in number and alert to any disturbance, which they will investigate at once.

Fanning behavior may be noted at hive entrances during hot summer days. Fanning sets up a current of air through the hive, cooling the interior and driving off excess humidity from ripening honey. Fanning will also occur when bees are shaken from frames in front of a colony, or when a swarm of bees is entering a brood box. In such cases the workers bend the tips of their abdomens down to expose the Nasanov or scent gland, located between the sixth and seventh segments (figures 5 and 6). The volatile secretion from this gland is carried on the air current set up by fanning, and serves to orient and attract other bees towards its source. Exposure of the Nasanov gland may also occur at food sources to aid new foragers in location.

FIGURE 6.
Worker bee fanning while exposing Nasanov (scent) gland.

Honey bees have two pairs of wings, which are normally folded along the back at rest. The rear wing has a row of hooks (hamuli) on its leading edge (figure 7) which fasten to a fold in the trailing edge of the fore wing, serving to hold each set of wings together for fanning or flight.

Foraging duties begin at about three weeks of age and continue for the remainder of the worker's adult life. During this time pollen, nectar, water and propolis are gathered in the field and brought back to the hive, where they are transferred to house bees which take over the processing and storing tasks. At the height of the summer season field bees live about three weeks before becoming worn out and dying.

Although there is a sequence of age tasks performed by worker bees, bees of any age can perform any of the tasks required to ensure normal colony functioning. In a colony made up solely of young workers, for example, some will never feed brood or clean house but will go directly to foraging, while others will continue to perform house duties, illustrating that there is some flexibility in the system, depending on the needs of the colony and the stimuli received by the workers.

Drones — Drones are produced primarily in the late spring and early summer. They perform no specialized tasks within the hive, serving only to mate with virgin queens. Mature drones, a week or more in age, leave each hive on warm, sunny days, congregate from a radius of several miles and fly together in what is called a "drone comet". Virgin queens on mating flights attract the drone comet by visual and olfactory means, with mating occurring on the wing. At the end of the summer the remaining drones are usually forced out of the hive.

FOOD REQUIREMENTS, COLLECTION AND PROCESSING

The bee-plant relationship — Bee species and the flowering plants are thought to have evolved together, with the interrelationship centered around the production and collection of nectar as a food source. Without flowering plants bees could not live; without bees, many species of flowering plants would not exist. The hairs on the body of the bee are feathered to facilitate capture of pollen grains, and pollination of a flower often occurs as a by-product of a bee's search for nectar. Nectar can be looked on as a "bribe" or "reward" offered by the flower to the bee in exchange for pollination. Other floral factors which help to attract pollinating bees include bright colored, showy flowers, and floral aroma. Color may act as a long distance attractant while aroma may stimulate landing and the search for nectar and pollen. It is interesting to note how closely these features are related, for when a flower has been pollinated and fertilized, nectar secretion and aroma production cease almost at once.

Nectar is secreted by glands called nectaries (figure 8), which are generally located within the flower but which may be extrafloral in some plant species. Pollen is the male sex cell of the plant and is produced within special organs called anthers, which along with their supporting filaments make up the stamens. The female sex cells, the eggs, are located within the ovary, located at the base of the pistil. Generally the stamens, pistil and nectaries (figure 8) of bee-pollinated plant species are located in such a manner that when the bee probes the flower for nectar she must brush by the anthers and the receptive area of the pistil. Pollen grains from a previous flower of the same species, caught in the feathered hairs of the bee, adhere to the receptive, often sticky, stigmatic surface as the bee pushes past. The pollen grains will germinate on the stigmatic surface and send pollen tubes to the ovary, through which the male nuclei travel. Fertilization of a flower occurs when the nuclei of pollen grain and egg unite.

Collecting nectar and pollen — Nectar, pollen and water are the three basics required for the honey bee

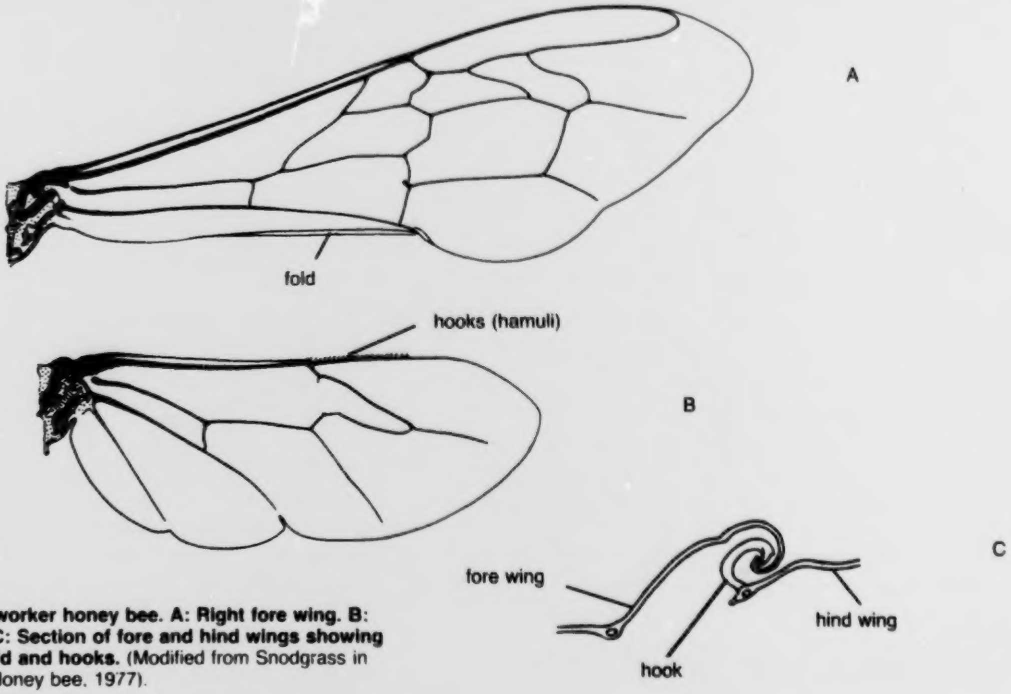


FIGURE 7.
The wings of the worker honey bee. A: Right fore wing. B: Right hind wing. C: Section of fore and hind wings showing interlocking by fold and hooks. (Modified from Snodgrass in The Hive and the Honey bee, 1977).

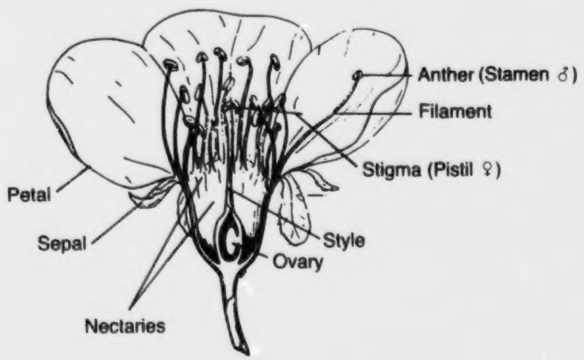


FIGURE 8.
Longitudinal section of a flower. (Modified from Free, 1976).

colony to thrive. Nectar and honey are sources of carbohydrates for energy, for bees as well as humans. Pollen is the source of protein for larval growth and development and adult development and maintenance. Pollen also supplies many vitamins and minerals as well as lipids (fats). Water is of great importance in the colony, making up a large proportion of the larval body weight and being necessary in the proper functioning of tissues and organs of both immatures and adults. Water is used to dilute stored honey and syrup to feed to the brood, and also plays a major role in temperature and humidity regulation within the hive. Whether a worker bee collects nectar, pollen or water will depend on conditions in the hive at that time, and will change with changing colony needs. Generally, the field force works within a 3 km radius of the hive but can forage at much greater distances if necessary. Inclement weather conditions shorten this radius.

One of the most interesting and important facets of foraging activity is the fidelity of the honey bee to the crop on which she forages. On any one trip the honey bee will usually visit flowers of only one plant species. It is this characteristic of the honey bee which makes her such an effective cross-pollinator. In fact, given constant conditions and a steady nectar flow the bee may continue visiting the same crop for several days or even weeks. However, if conditions change in the hive or in the field, the bee may change to another crop or another commodity or both.

The worker honey bee possesses specialized equipment enabling her to gather and carry quantities of nectar, water and pollen back to the hive. The nectar-collecting apparatus consists of specialized mouthparts which come together to form a tube, a muscular "honey pump" in the head to draw liquids up through the tube, a long oesophagus, and a honey stomach for short-term storage (figure 9). The honey stomach is not part of the digestive tract of the bee but instead is part of the oesophagus, modified to a thin-walled expandable sac. The forager will visit as many flowers as necessary to obtain a full load of nectar, which comprises about 50 micrograms (1 mg = 1000 micrograms). Numbers of flowers visited per trip will

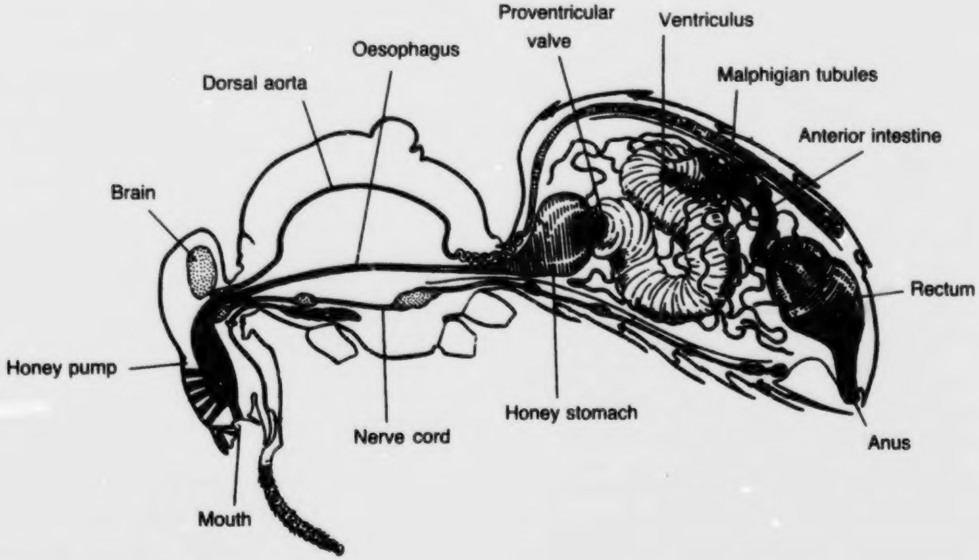


FIGURE 9.
The internal organs of the worker honey bee. (Modified from Snodgrass in the Hive and the Honey Bee, 1977).

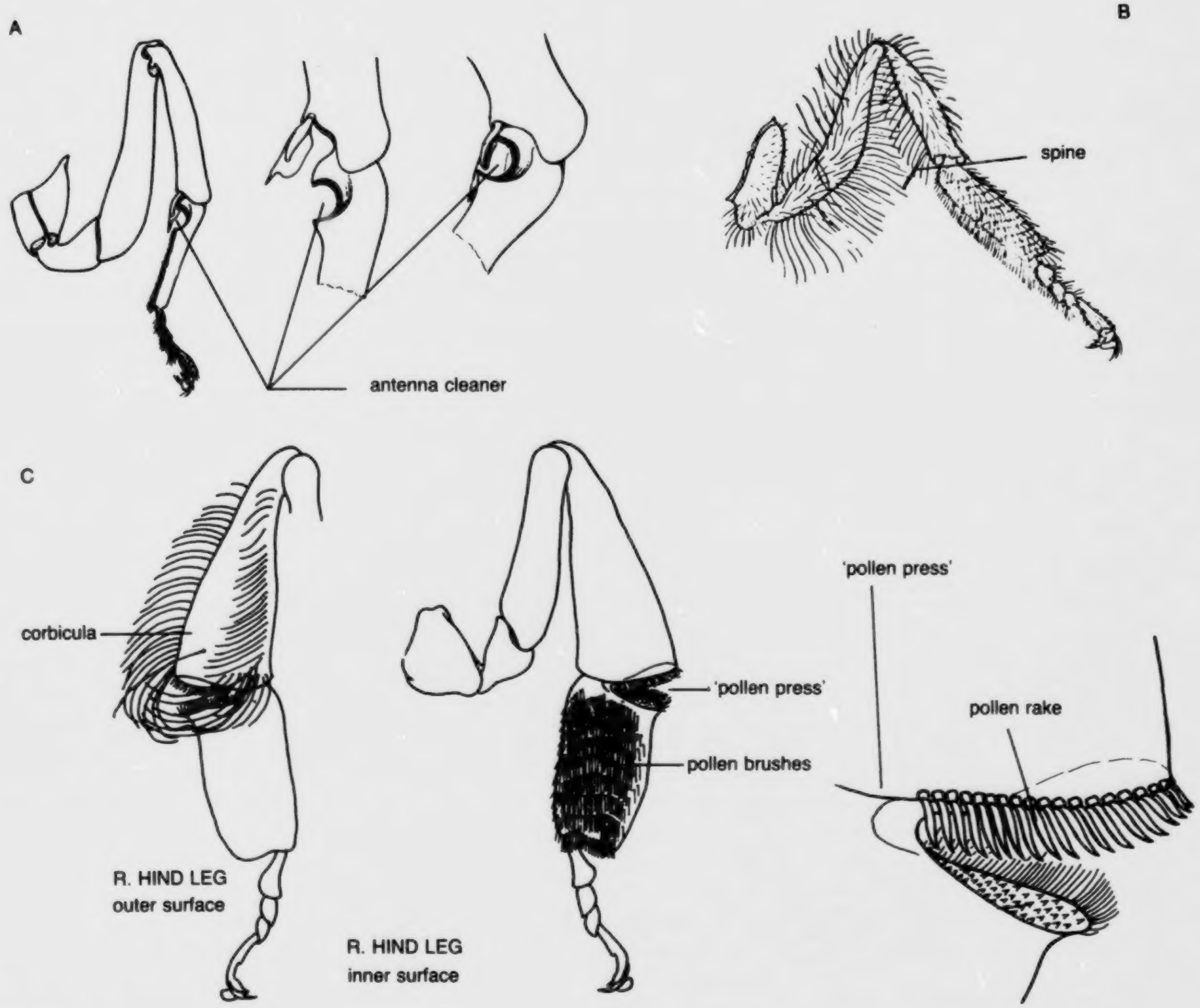


FIGURE 10.
The legs of the worker honey bee. A: right foreleg showing the antenna cleaner opened and closed. B: right middle leg. C: right hind leg and pollen basket (corbicula). (A and B modified from Snodgrass in the Hive and the Honey bee, 1977; C modified from Dade, 1977).

vary from a few to several hundred, depending on the plant species and amount of nectar available per blossom.

Honey bees communicate the location and quantity of nectar sources to the other bees within the hive by means of the bee dance. Direction, distance and quality of the nectar source can be determined by the duration and vigor of the dance. Thus other bees may be recruited to go to the food source by a scout bee or forager who returns and performs the dance within the hive, occasionally stopping to offer tastes of nectar to potential recruits. It is likely that the floral odor clinging to the bee as well as the odor and flavor of the nectar aid in communicating the whereabouts of the food source.

A honey bee collecting pollen only will scrabble at the pollen-bearing anthers of the flower with her mandibles (jaws) and front legs. Often, though, pollen grains which are caught in the featherlike hairs of the honey bee as she probes the flower for nectar are then collected by a series of brushing and cleaning movements into pellets on the hind legs. The legs of the honey bee are modified to comb pollen from the body and gather it into special baskets for transport back to the hive (figures 10 and 11). Both fore and middle legs carry brushes of stiff hairs for cleaning pollen from the head and thorax. One section of the

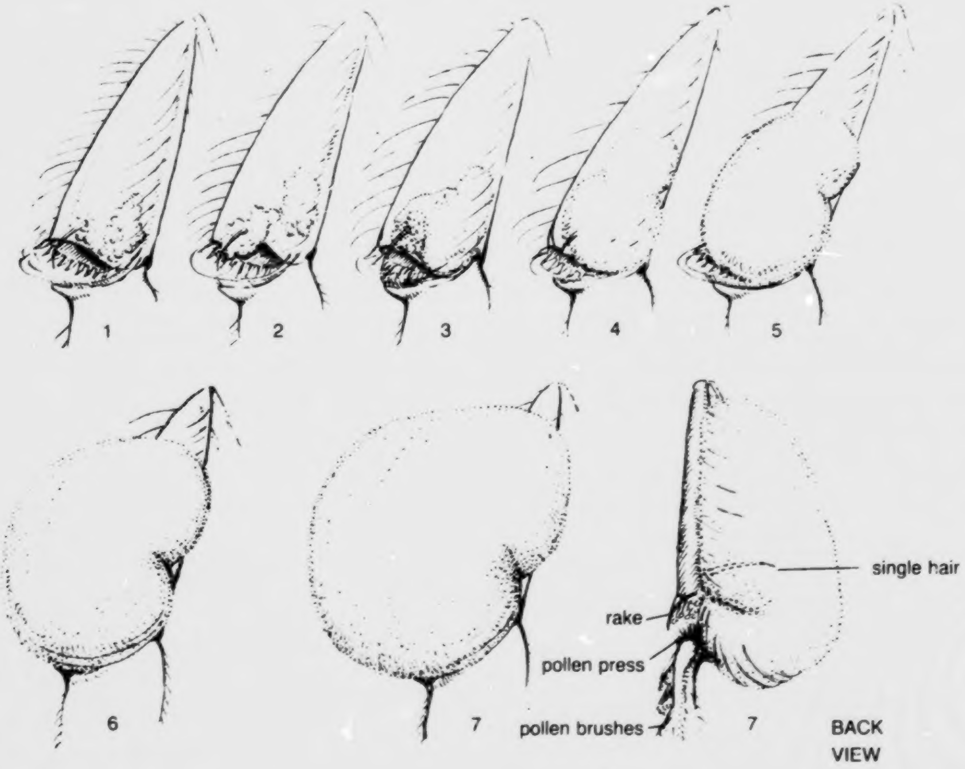


FIGURE 11.
The progressive packing of the pollen load in the corbicula.
(Modified from Hodges, 1974)

hind legs, the basitarsus, has many rows of hairs which can comb the accumulated pollen from the other legs, while another section, the tibia, is smooth and concave, with a single hair which pins the pollen load in place. The joint between these two sections acts as a pollen press. Pollen transferred to the combs is worked into the press and then pressed into the pollen baskets or corbiculae, as the concave tibiae are called (figures 10 and 11). Pollen pellets contain some nectar or honey added by the bee to help stick the pollen grains together.

The forelegs also each carry a specialized antenna cleaner (figure 11), through which the antennae are drawn to remove pollen and debris. With constant cleaning of the eyes and the antennae, which are the primary sensory organs (figure 2), the honey bee remains continually able to perceive changes in her environment.

Food processing and storage — Back at the hive, the field bee will offer her load of nectar to house bees, who then take over the processing, allowing her to go out again. Nectar is composed primarily of the three sugars sucrose, glucose, and fructose, in varying proportions depending on the plant species. Enzymes are added to nectar by both field and house bees which invert the sucrose, changing it to the honey sugars glucose (dextrose) and fructose (levulose). Nectar contains from 40 per cent to 80 per cent water; the excess water in the unripe honey is evaporated by house bees and placed in cells in a thin film or small droplets with relatively large surface areas, and by the continual air movement set up by fanning at the hive entrance. Once the honey reaches a moisture level of about 18 per cent it is transferred to storage cells and covered with wax cappings.

If the field bee brings in a load of pollen she will find an empty cell or one containing some pollen, dangle her hind legs into the cell and, using the spines on her middle legs (figure 10) to loosen each pellet, kick off the pellets. House bees tamp the pollen into the cell and cover it with a thin film of honey. Pollen stored in this manner undergoes several changes, noticeably a change in acidity and starch content, and is sometime called "bee bread". There appears to be no difference in nutritive quality between freshly-collected pollen and bee bread. Bee bread undergoes a fermentation process rather like silage, and this process contributes to its storage life in the comb.

Robbing honey from other colonies — Since the field force is attuned to searching for food, when no nectar is available the bees may try "foraging" at another colony, a situation known as robbing. Robbing bees take on a "furtiveness", hovering near other colonies, darting away if challenged by guard bees, and endeavoring to slip by the guards in search of stored honey. Weaker colonies with few guard bees may be especially preyed upon, and their honey stores may be seriously depleted or completely cleaned out.

II. GETTING STARTED IN BEEKEEPING

Beekeeping is a fascinating occupation, one which constantly attracts newcomers and stimulates them to try their hand at keeping a few hives. Before becoming irrevocably involved, however, it is wise to do as much homework as possible. Local libraries may carry beekeeping texts and magazines. The provincial apiculturist's office has many pamphlets on hand which will be sent on request. Larger towns often have a local bee club which can be a very good source of practical information, as well as starting point for obtaining bees, hives and other equipment. An experienced beekeeper may be able to supply bees and equipment, and certainly will be able to supply advice. Although reading about beekeeping will help the beginner to gain some familiarity with beekeeping basics, demonstration of techniques by someone with experience will be invaluable.

WHAT IS BEEKEEPING?

Beekeeping is the ability to manage honeybee colonies in such a way as to: (1) obtain large (or maximum) adult populations to coincide with the major nectar flows of a given area, and to (2) utilize this population to the best advantage for collecting nectar and/or pollinating crops.

There are three basic problems common to beekeeping. They are determining when honey flows occur within an area, building colony populations in preparation for the main nectar flow periods and deciding what to do with colonies during nonflow periods. These problems must be addressed by beekeepers worldwide whether they operate one colony or many, if maximum honey production is to be attained. Surveys to determine available bee forage and blooming periods, scale colony records, weather records and a study of farming practices will be necessary in determining honey flows.

Maximum colony build-up is dependent upon good beekeeping practices, such as using good genetic stock, periodic queen checks, properly situated apiaries with hives arranged to minimize drifting, adequate feeding, disease prevention, swarm prevention and the provision of adequate storage space for nectar and brood. After the flow period the decision must be made whether to kill colonies, winter colonies or to winter a proportion of the colonies. If the beekeeper is situated in an area with abundant bee forage, and if weather conditions are favorable for bee flight and nectar secretion, then the beekeeper will be successful in producing a honey crop. As the commercial beekeeper must manage many hives simultaneously, it is important that the apiary site be managed as a unit rather than as a number of individual hives. This entails each hive within the apiary receiving the same treatment such as feeding, queen checks, supering, etc. However, this objective is impossible to attain if population shifts or imbalances occur within the apiary caused by poor queens, disease, drifting, swarming, or other management related reasons.

THE STING

The aspect of keeping bees which horrifies the general public is that tiny piece of chitin called the sting. It is often said that the sting is only ⅛ inch long — the other six inches are your imagination. More important than the shock of the initial impact, however, is the fact that a small percentage of the human population is highly allergic to bee venom. The beginning beekeeper should be aware that this possibility exists. The first few stings often cause local swelling and itchiness which may last some time. Most people become accustomed to the bee venom with time, but some become more sensitized with each sting. Generalized reactions, where symptoms occur away from the site of the sting, indicate a dangerous sensitivity. These symptoms include constriction of breathing passages, itching and hives, swelling away from the site of the sting, nausea or abdominal cramps, dizziness, and confusion. If any of these symptoms occur the beekeeper should seek medical help immediately.

The bee's stinger is made up of a 3-piece barbed shaft attached to a venom sac (figure 12). When a bee stings and flies away the whole apparatus is usually left behind. Thus when removing the sting it should be scraped away with a sideways movement of the thumbnail; grasping and pulling will force more venom from the sac down the hollow shaft into the wound.

Honey bee workers can sting only once, and die after doing so. Drones have no sting, while the sting of the queen is not barbed and is used solely against rival queens; the queen can sting repeatedly if necessary.

To avoid more than the occasional sting the beekeeper should wear smooth, light-colored clothing, preferably cotton and definitely not wool. Long sleeves and gauntlets, a bee veil tied securely around the collar, and pant legs tucked into boots or tied at the ankles will prevent any untoward surprises from occurring.

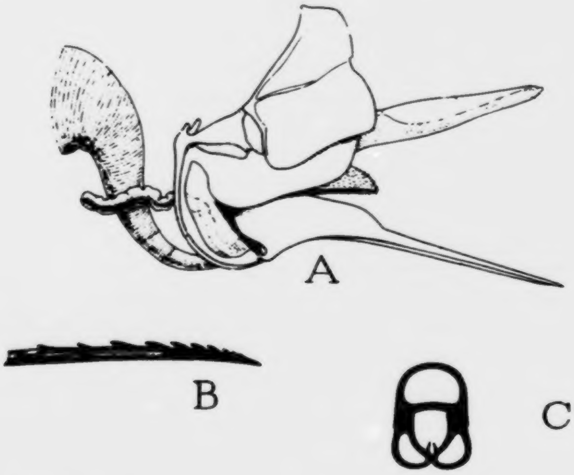


FIGURE 12.
The sting of the worker honey bee. A: Outline of the sting structure. B: The barbed lancet. C: Cross section of the sting shaft. (Modified from Snodgrass in the Hive and the Honey bee, 1977).

PURCHASING BEES

The beginning beekeeper should generally start with two or three colonies. Having one colony does not allow any comparisons to be drawn, and if the colony goes queenless there is no source of fresh eggs for new queen production (see section 11). To start a colony of bees, the beekeeper may buy a package from a package producer in the southern United States, an overwintered colony from another beekeeper, or he or she may hive a swarm of bees. The first two methods are probably a more reliable way of obtaining bees. The best time of year to begin is the early spring; the beekeeping season begins in April. Packages must be ordered some time before April and ordering may be done directly, through a club or association or through a commercial beekeeper. Packages are essentially screened boxes filled with 0.9 to 1.8 kilograms of bees which have been shaken off frames into a funnel and tumbled into the box (figure 13). A queen in a screened cage and a can full of sugar syrup are added and the packages shipped by truck from California, Texas, or other package-producing states to their destination in Canada. If overwintered colonies are to be purchased they should first be inspected by a government apiary inspector for any evidence of bee diseases; the seller will then be issued a permit to sell which the buyer should ask to see.

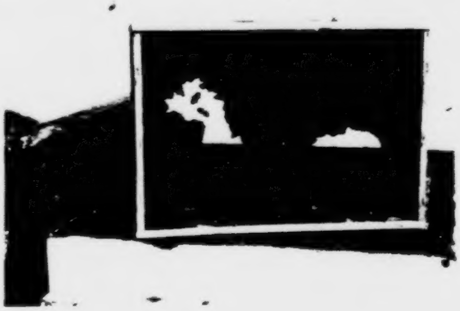


FIGURE 13.
A two-pound package of bees ready for hiving. (Photo D. Nelson).

BASIC BEEKEEPING EQUIPMENT

The basis for the movable frame hive is the "bee space" of 8 mm or $\frac{5}{16}$". In a naturally-built bee nest the bees leave this space as a passageway between combs. By duplicating in man-made hives what colonies build in nature we find that the combs are left free from one another, and that the spaces between the combs and between the supers are not filled in with additional combs called burr comb, making each comb easily removable for examination. Thus the inner dimensions of a modern bee hive incorporate the length and width of each comb plus the bee space between and around the combs.

The boxes which make up the bee hive are called supers, bee boxes, or hive bodies. They may also be referred to as brood chambers, which house the brood nest, and honey supers, in which surplus honey is stored. Most supers are of standard length and width (figure 14) to allow exchange of frames and supers from hive to hive. Standard or Langstroth equipment has higher resale value for this reason. Supers of different depths are available, so the beekeeper can use a shallower honey super for easier lifting, if desired. Equipment of other dimensions than those shown in figure 14 is also available.

Each Langstroth super, be it brood chamber or honey super, holds a maximum of ten frames, each of which holds a comb of beeswax. Many beekeepers prefer to use only nine frames in their supers to allow a little extra space for manipulation. Beeswax combs begin as sheets of wax foundation which are embossed with the bases of the hexagonal cells, about two per cm. These sheets may be pre-embedded with vertical wires for extra support. Frames, again of standard dimensions, are cross-wired and the foundation inserted into slots or grooves in top and bottom bars (figure 15); then the cross wires are embedded into the wax by means of a spur embedder or an electric current. When placed in a strong colony with plenty of honey stores or available sugar syrup the foundation is drawn out and built upon to form a comb. In general, frames in honey supers hold newer combs which are light or golden in color, while brood chambers hold darker-colored combs. Successive generations of brood in a comb cause this darkening through deposits of larval skins and the polishing of cells with propolis between generations. Dark-colored combs are preferred by the queen for egg-laying, possibly because of greater heat retention properties. Because of the time factor involved in production of good brood combs they are a valuable part of the beekeeping operation and should be properly cared for.

Generally two brood chambers and from three to five honey supers are necessary per colony. The hive also requires a bottom board and a top cover. The bottom board (figure 14) should be kept off the ground, either by nailing cleats on the bottom or by placing the hives on pallets or some sort of hive stand, in order to preserve the bottom board from moisture. An inner cover may be placed over the top box (figure 14); this rimmed board may have a 5 cm entrance cut from the rim, as well as a 5 cm hole drilled through the cover for feeding purposes. Over this cover is placed the outer cover. The telescoping outer cover is often tinned for added protection. These two covers may be amalgamated into one by using 19 mm plywood cut to the dimensions of the supers, with a small hole drilled in the centre and a 5 cm entrance dadoed on one end. Whichever design is chosen, outer covers as well as supers and bottom boards must be painted with two coats of good-quality paint for protection against weathering.

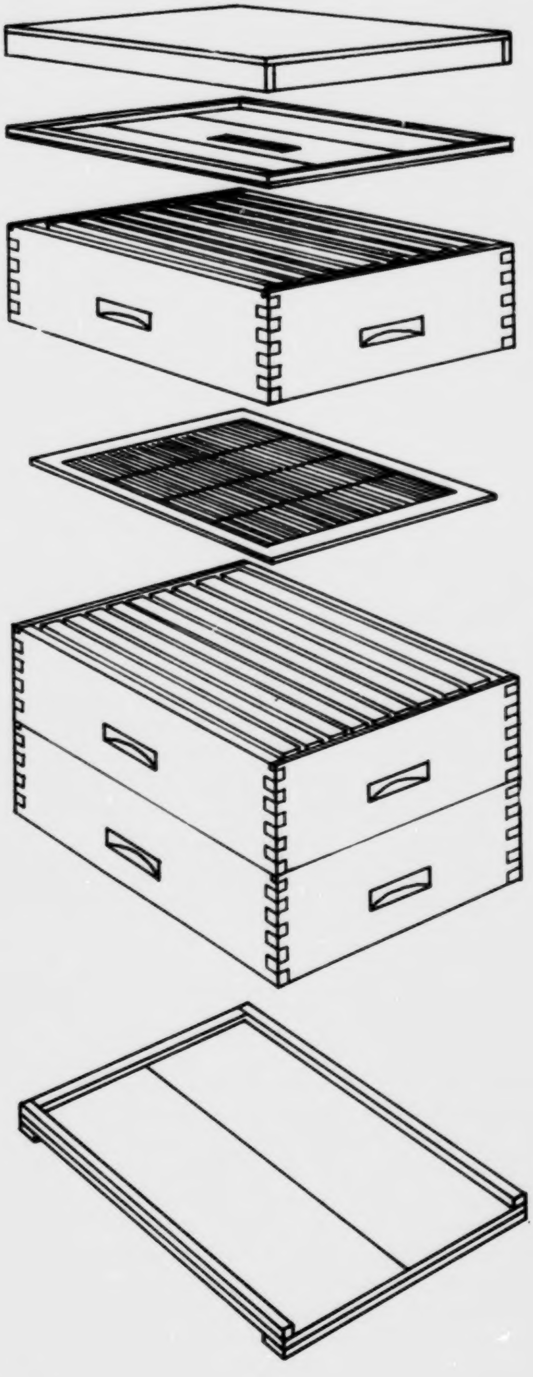


FIGURE 14.
Components of the bee standard bee hive.

The beginning beekeeper may buy used equipment, order preassembled new equipment, order it unassembled and assemble it at home, or build it from scratch. If overwintered colonies are purchased they will be in either one or two brood chambers, and the seller may also supply three or four honey supers for each colony. Beekeepers will often sell used equipment with or without bees. Drawn combs, especially in the brood chambers, are a definite advantage over foundation, but the buyer must beware of the possibility that the equipment may carry the dormant stages of any of a number of bee diseases. Again, there should be a permit to sell the equipment on which will be written any disease history. Combs should also be inspected before purchasing for general condition, including the percentage of drone comb, mouse or moth damage, and broken frames.

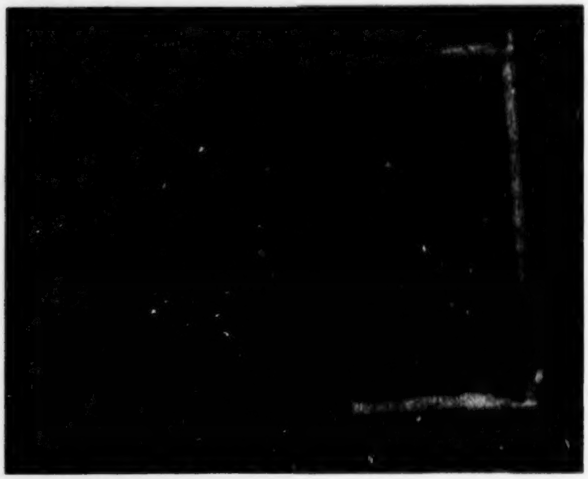


FIGURE 15.
Left: A wired frame with embedded foundation. Right: a wired frame. Foreground: A sheet of wax foundation.

Equipment may be ordered assembled from some beekeeping supply houses, but is less expensive if assembled at home. For beekeepers who wish to assemble or construct their own equipment, a pamphlet outlining hive construction entitled *Beehive Construction* (Publication 1584) is available through Information Services, Agriculture Canada, Ottawa K1A 0C7, or through the provincial apiculturist.

TABLE 2.
EQUIPMENT NECESSARY TO OPERATE A 5 COLONY APIARY

ITEM

Hive Equipment

25 supers
5 metal covers
5 bottom boards
225 Hoffman frames
2 lb frame wire
spur embedder
5 division board feeders
2 carbolic acid boards
38 lb foundation – approx. 225 sheets
5 bee escape boards
1 gallon of paint

Personal Equipment

smoker
hive tool
veil
helmet
coveralls

Honey House Equipment

4 frame extractor & motor
electric uncapping plane or scratching fork
storage tank with honey gate – 650 lb capacity
nylon straining cloth

ITEM

Yearly Requirements

5-2 lb packages of bees – optional depending on whether wintering or not
1 lb oxytetracycline
Cyanogas (1 lb) – optional
sugar – 40-200 kg

OPTIONAL ITEMS

bee brush
bee gloves
5 hive stands
50 frame rests
eyelet punch
1,000 eyelets
honey gate strainer
fumagillin – 0.5 g
bee journals
10 lb pollen substitute
bee allergy Anakit
5 queen excluders

Besides bee hives, the beginning beekeeper will find three pieces of equipment essential for colony examination: the smoker, the hive tool, and the bee veil (table 2 and figure 16). All three can be obtained through any beekeeping supply house. Without a smoker and a hive tool or suitable substitute one will find any manipulation of super or frame difficult due to propolizing by the bees and to the angered guard bees. With a smoker and hive tool, the bees may be kept quiet with a few puffs of smoke while the beekeeper gently pries apart bee boxes and frames to have a look inside. The bee veil protects the head and neck from the worker bees checking out the situation, whether angry or merely inquisitive. A pair of coveralls should be purchased for added protection. Gloves may be used while the beekeeper grows accustomed to handling the bees but are not recommended for constant use, as they make manipulation of frames more awkward.

Nearly any type of fuel may be used in a smoker. The aim is to have a constant source of cool smoke. Such fuels as burlap sacking, binder twine, rolls of cardboard, and wood shavings are all good fuels. A hot smoke may be cooled down by adding some green grass or leaves to the smoker.

FIGURE 16.
Bee veil with hat, smoker and hive tool.

THE COLONY EXAMINATION

Colonies should be checked during warm, sunny days with little wind, in order to avoid chilling of the brood and bees. As well, on days with good flight weather the field force is away from the hive, reducing the numbers of bees with which the beekeeper must work. On days of inclement weather foragers stay at home with nothing to do, and because older bees have a well-developed guarding instinct it is not advisable to bother the colonies too much on such days. Throughout the colony examination it is essential to remain calm and unhurried and to keep all movements as gentle and smooth as possible, for a crash-bang approach only serves to anger the colony and makes checking a chore instead of a pleasure.

The beekeeper should examine the colony with the following points in mind:

— are there fresh eggs? Newly-laid eggs generally denote the presence of a laying queen, even if she is not seen during each inspection.

— how does the brood pattern look? Is nearly every cell capped? Or does the frame have a spotty appearance, perhaps denoting a poor queen or a disease problem causing the death of some of the brood?

— does the colony have enough pollen? honey? space?

— are there signs of any disease problems?

The beekeeper should always work from beside the hive so that the entrance and flight path are not blocked. Hive tool in hand and smoker smoking, a few puffs of smoke are directed into the entrance(s). The outer cover is removed and placed upside down on the ground, and the inner cover is gently pried up. As soon as the inner cover is lifted, a few puffs of smoke are directed over the top bars of the frame. The smoke has a calming effect on the bees and if it is used each time the hive is opened the colony should remain quiet and gentle throughout the season. Without smoke, each time a hive is opened the colony will become a little more defensive, until the time comes when the inner cover is pried off and the guard bees fly up without hesitation and attack the intruder.

If the colony is in two or more brood chambers the upper chambers are pried apart, again using smoke between the chambers, and are placed diagonally on the outer cover. Starting with the bottom brood chamber, one of the outer frames is gently removed and leaned against the chamber to give room for further manipulations. Each frame is pried apart, removed and examined, then replaced, leaving room to get at the next one. It is important to avoid crushing and rolling bees, because the chemicals or pheromones released by crushed bees alarm the other workers, who then become more defensive and apt to sting. Once the frames have been checked they are pushed together and the outer frame replaced. The second chamber is then placed back on the first; each chamber may be checked in the same manner, again using smoke to prevent crushing of bees when the upper chambers are replaced. The inner and outer covers are then placed on top of the hive and the beekeeper moves on to the next one.

EXPANDING THE OPERATION

Once the beginning beekeeper has become initiated into the ways of the bee an increase in the number of colonies may be considered. This may be done by buying more colonies, by building equipment and buying packages, by splitting colonies or by a combination of these methods. Again, caution should be exercised in any kind of expansion, be it from two colonies or two hundred. Time and facilities available, suitability of the region and the potential honey market should all be considered. A slow expansion is much easier to handle than an instant tripling or more of colony numbers.

THE BEE ACT

Beekeepers in every province are required by law to register with the office of the provincial apiculturist. There are several purposes behind this requirement. Probably the most important is the ongoing inspection program for the presence of brood disease. If left unchecked, brood disease such as American foulbrood can spread rapidly through a beekeeper's equipment and from one beekeeper to another. Regular inspections by apiary inspectors help to pinpoint disease locations and prevent and control its spread, and have an educational value as well. When equipment changes hands, an inspector's report ensures that the buyer knows of any problems associated with the equipment.

Knowledge of the locations of beekeepers and their apiaries is valuable when widespread aerial spray programs are considered for insect pests such as mosquitoes or grasshoppers. Beekeepers in areas which may be affected can be notified without delay so that they may protect or move their hives. Government programs such as crop insurance, low interest loans, and compensation for bear damage are offered to registered beekeepers only. Registration is free, and registered beekeepers receive the apiculture newsletter.

III. NECTAR AND POLLEN PLANTS

A knowledge of the nectar and pollen producing plants in an area is an essential part of beekeeping. To quote from Le Maistre's 1943 *Beekeeping for Beginners in Alberta:*

> An intimate knowledge of the clover acreage in any given district should be sufficient guide to its suitability for honey production, when due consideration is given to the question of rainfall.

While this quote does not mention canola or alfalfa, it points to the fact that even with the best management bees cannot produce honey without a source of the raw materials, nectar and pollen.

While control of nectar production is to some extent genetic, any factor which affects either the day-to-day or long term well-being of the plant will also affect nectar secretion. Different plant species have different requirements for optimum secretion. Soil moisture, precipitation, air temperature, and number of sunshine hours may all affect the quantity of nectar secreted and its concentration. In a drought situation, for instance, fields of canola may bloom for only a short time, and during that time the quantity of nectar secreted will be minimal; any available water will first be utilized for plant maintenance and development.

Beekeepers refer to a "honey flow" when they see surplus honey being stored in their hives. Perhaps the term "nectar flow" is more apt, since it is the nectar which flows from the flowers and which is collected and changed into honey by the bees. The nectar flows are generally fairly well delineated on the prairies, whereas in other areas of Canada, such as the west coast, the flows may be less intense and stretched out over longer periods. There are three nectar flows in most regions of the prairies: the spring flow, the main flow, and the late or fall flow. Honey from the lesser spring and fall flows is usually left for the bees, for

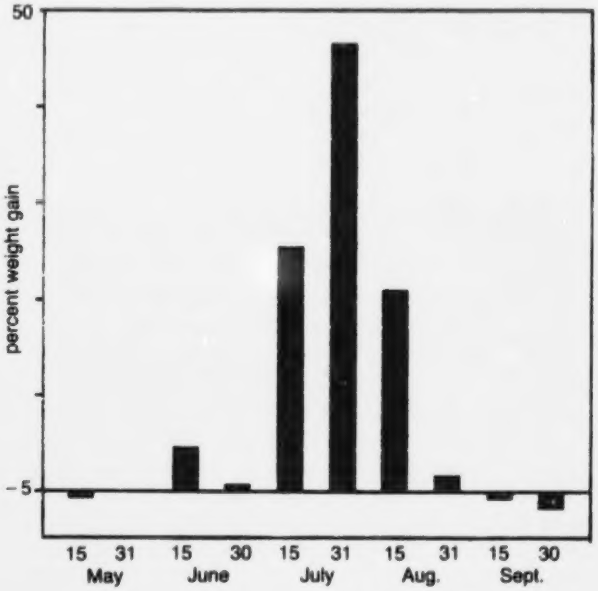


FIGURE 17.
Scale Colony Gains, Beaverlodge 1954-76.

spring buildup and overwintering purposes respectively. The main nectar flow supplies the surplus honey which is harvested by the beekeeper. Generally the three nectar flows are accompanied by pollen flows, for nearly all of the major prairie nectar plants are visited for pollen as well, with the exception of alfalfa.

The beekeeper should be aware of the time of commencement and the duration of nectar flows in his or her area. Records of scale colony gains and losses have been kept at Beaverlodge Research Station since 1954. These dates (table 3 and figure 17) will give the beekeeper a general idea of what to expect, but allowance must be made for different regions, climatic regimes and cropping patterns as well as yearly variations in weather patterns. Generally, the spring flow occurs from the end of April to the end of May or mid-June, the main flow from the end of June to the end of July, and the late flow in August and sometimes into September. In order to know when the flows and dearth periods are occurring the beekeeper may wish to add a scale colony to the home apiary. With periodic scale readings such information is immediately available, and management techniques can be adjusted accordingly.

TABLE 3. Records of average nectar flow dates at Beaverlodge, Alberta (latitude 55° N) from 1954 to 1976. Pollen was obtained from all crops except alfalfa.

Willow	May 10 - June 10
Dandelion	May 27 - June 27
Hawksbeard	June 1 - Frost
Alsike clover	June 20 - Frost
Canola	June 28 - August 10
Alfalfa	June 28 - Frost
Sweet-clover	June 28 - Frost
Red clover (single cut)	July 10 - Frost
Fireweed	July 5 - August 5

Taken from Henn, G. D. and D. L. Nelson, 1977. An analysis of Beaverlodge nectar flow records. Agriculture Canada Contribution No. NRG 77-6.

Nectar plants may be divided into major and minor categories. Bees collect nectar and pollen from many different plant species but only a few of these plants grow in enough profusion and produce enough nectar that a surplus of honey may be harvested. As well, nectar production by a particular plant species may vary under different soil and climatic conditions. Plants considered a major nectar source in one region may be only a minor source in others. Yearly variations may also cause minor honey plants to occasionally yield heavily or major plants to yield poorly. Again, the beekeeper must become familiar with the peculiarities of his or her own region through observation of flowering plants and dates, and weather and scale colony records.

Major nectar plants include willows, dandelions, canola, clovers, sunflower, faba bean, alfalfa, sainfoin and buckwheat. Minor honey plants include caragana, hawksbeard, pin and choke cherries, saskatoon berry, currant, raspberry, sowthistle, aster, thistles, goldenrod and fireweed. Poplar contributes some pollen in the early spring. As well, there are many horticultural crops and ornamentals which are good nectar and pollen plants. Apple and other fruit trees, lilac, some of the honeysuckles, poppies, many of the herbs such as borage and thyme, to name but a few, all yield nectar or pollen and are freely visited by foraging honey bees. For the backyard beekeeper it may even be desirable to plant a "bee garden" to supply the bees with extra nectar and pollen sources.

A few plants yield nectar or pollen which is toxic to honey bees or nectar which, when converted to honey, is poisonous to humans. One case of bee poisoning in the Brooks area of Alberta is documented in the 1935 annual report of the apiculture branch. From 50 to 90 per cent of the field bees were lost from affected hives during the middle of June. The cause of the poisoning was pollen or nectar obtained from narrow-leaved milk vetch, *Astragalus pectinatus*. Fortunately, cases of poisoning are rare and there are very few plant species in North America which may cause such problems. Other plants which produce honey toxic to bees or humans include other *Astragalus* species, mountain laurel *(Kalmia* sp.), rhododendrons and azalias.

IV. SUPPLEMENTARY FEEDING

There are several times during the year when the food stores in a honey bee colony may run low. Without supplementary feeding at these times the colony faces at least a setback and at worst death through starvation. When close to starvation workers carry larvae and pupae out of the hive entrance and drive drones out. Adults can survive for a short time on their body reserves, but will eventually die if food does not become available. A colony which is rearing brood and rapidly building up in numbers will go through its honey and pollen stores amazingly quickly. Various authors estimate that a colony should have on hand at least 14-18 kg (about five or six frames) of stored honey at all times during the beekeeping season, should a dearth period occur, as well as stored pollen around the brood area. For the winter, of course, far more honey will be needed.

CARBOHYDRATE SUPPLEMENTS

Supplementary feeding of a carbohydrate will be necessary during the spring for both overwintered and package colonies and for new divisions, especially when there is much foundation to be drawn out. By spring the winter stores are usually much depleted as a result of an acceleration in brood-rearing. A delayed spring flow, or a spring with much inclement weather preventing foraging, increases the need for supplementary feed. There is often a dearth period between the spring and main nectar flows, when the dandelions have finished and before the sweet-clover and canola begin blooming. At this time colonies are raising a lot of brood and are rapidly expanding in size; a food shortage may set them back to the extent that they are not able to take full advantage of the main nectar flow. The beekeeper must keep careful watch on his or her colonies during the spring brood-rearing period.

Supplementary feeding in the spring serves to stimulate both package and overwintered colonies to greater brood-rearing efforts. Even if food stores are available in the hive, many beekeepers choose to feed some sugar syrup to colonies for stimulative purposes before the spring nectar flow begins.

Types of feed — Beekeepers feed a variety of sugar types to their bees. Frames of capped honey are certainly the easiest way to feed, and most commercial beekeepers do not extract honey from the brood chambers but rather leave it for their overwintering colonies or use it in making up brood chambers for next season's packages (see section 5). Extra frames of honey may be stored over the winter and given back to the bees in the spring when colony stores are low.

Sugar syrup made from refined white sugar is the most widely-used supplementary bee feed. Brown sugar and molasses contain a higher percentage of impurities which are indigestible by bees and which may cause a dysentery problem, especially noticeable in wintering colonies. White sugar contains almost no impurities and therefore makes a better bee feed. The syrup is mixed in a 2:1 sugar:water mixture (by volume) for both fall and spring feeding. To make small quantities of syrup a garbage pail and hand power may be used. For large quantities a tank with a mixer will be necessary. Hot water is useful in mixing 2:1 sugar syrup, but boiling the syrup is unnecessary and may result in caramelization, making the syrup less digestible for the bees. Five litres of 2:1 sugar syrup will increase a colony's food stores by about 3 kg.

Feeding dry sugar to honey bee colonies is not generally recommended. Bees will consume dry sugar but will also often carry the sugar out of the hive and drop it in front of the entrance. In an emergency, if other means of feeding are not immediately available, dry sugar may be spread on the inner cover around the open feeding hole so that the bees may have access to it. Another inner cover may be placed over the sugar to enclose it.

Syrup may be made from honey by diluting it from 17 per cent moisture to about 33 per cent moisture with a quarter volume of water for a 2:1 syrup, or by about a half for a 1:1 syrup. Honey which has darkened through overheating, for instance in a wax melter, may be saved for spring feed but should never be used as fall feed, for overheating causes caramelization and a higher percentage of indigestible matter, as well as the accumulation of toxic substances. If fed in the fall for winter stores, when the bees cannot fly to void their faeces, such honey may lead to dysentery problems within the hive, and premature death of affected workers. Only honey from colonies known to be free of diseases should be fed back to bees, for disease organisms may be carried in honey, and if fed to a colony, may cause an outbreak of disease. Sugar syrup may be mixed with honey syrup to prevent the honey syrup from cystallizing.

Liquid invert sugar is manufactured in two grades, 50 per cent and 100 per cent, primarily for use in the baking industry. Acid is added to sucrose which breaks the sucrose molecule into its component parts, glucose and fructose, a process known as acid hydrolysis. Substances toxic to honey bees which are produced during acid hydrolysis make invert sugar produced by this method unsuitable for use as a bee feed.

Another carbohydrate food which does appear suitable for feeding bees is high-fructose corn syrup, also referred to as isomerized corn syrup. This is syrup made from cornstarch by the addition of enzymes, which break the starch down to glucose and then convert some of the glucose to fructose. Isomerized corn syrup is available in two forms — 42 per cent fructose and 55 per cent fructose. Mixed results have been reported from beekeepers using the 42 per cent formulation, possibly owing to a varying polysaccharide content causing some bee mortality. The 55 per cent formulation appears to make a better bee feed. The moisture content of this syrup is about 23 per cent, and it is diluted by about a third of its volume with water before feeding to colonies.

Although isomerized corn syrup seems practical as a bee feed, being lower in cost at the time of writing than sucrose, there are handling problems associated with it which make it impractical for the hobby or sideline beekeeper. Since it is shipped by tanker or in 200 L drums the beekeeper must have some means of storing large volumes of drums under heated conditions, preferably over 26°C, as at lower temperatures the syrup will crystallize. The beekeeper must also have a way of liquefying crystallized syrup. The major problem with isomerized corn syrup is in adulteration of honey, be it inadvertent or intentional. If it is left on the colonies in the late spring it may become incorporated into the honey produced at the beginning of the major nectar flow. If using isomerized corn syrup, care must be taken that feeding it to colonies is halted by the beginning of June, or two to three weeks before the main nectar flow is expected to begin, and before any honey supers are added to the hives.

Types of feeders

Whatever type of syrup is used it is important to situate it as close to the colony cluster as possible, so that it is accessible even during cold weather. The feeder must fulfill this need and must also contain the syrup so that it is not exposed, as exposed syrup will promote robbing. Before feeding, colonies should be level or tipped slightly back so that should leakage of syrup occur it will gather at the back of the bottom board, rather than running out of the entrance and attracting potential robbers.

There are several types of feeders available:

1. Hive top feeder — This feeder (figure 18) is of the same length and width as a super, 10 cm or more in depth, and sits directly over the brood chamber. It is divided into two with a slot down the middle to allow bees access to the syrup. The slot is screened over so that bees have something to cling to as they feed, and do not float away and drown. The standard hive top feeder holds about 9 L of syrup, although some beekeepers may alter the depth so that more syrup can be fed. It has some problems associated with leakage if the joints are not tight, and takes a fair amount of storage space. Some bee loss through drowning is common.

Older supers may be altered and used as top feeders if they are adequately braced and lined to prevent leakage. Substantially more syrup can be fed at one time when using other types of feeders, which is an advantage when feeding in the fall. In addition, commercially-manufactured top feeders are available from bee supply firms.

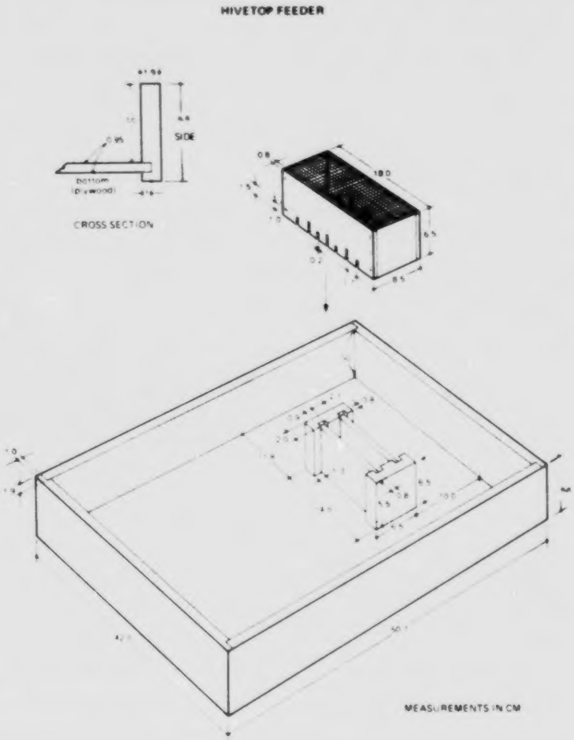


FIGURE 18.
Hive top feeder. Floats should be used to prevent bees drowning.

2. Division-board or frame feeder — This feeder is constructed to the same outer dimensions as a frame (figure 19) and replaces an outer frame in the brood chamber. It is ideal for feeding smaller amounts of sugar syrup, for example, for spring feeding of packages, as it holds from two to four litres. Generally the frame feeder is made of wood, hardboard or plastic, with wooden floats or screening inside to allow the bees access and to prevent drowning. The wooden frame feeder may have some leakage problems if joints are not sealed properly.

3. Friction-top pail — The 13.6 kg friction-top pail (figure 20) is the most widely used feeder in commercial apiaries. Its size makes it ideal for feeding large amounts of syrup to colonies in the fall or to overwintered colonies needing feed in the spring. The pails stack and take little storage space when not in use.

Lids for feeder pails are commercially available which

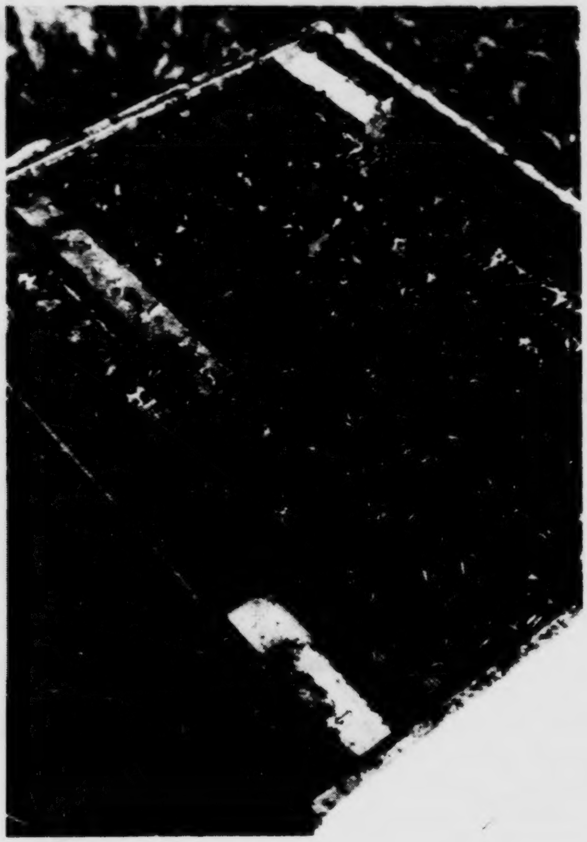


FIGURE 19.
Division board or frame feeder. A wooden float should be inserted to prevent bees drowning.

have a rubber ring seal and several small holes covered with a piece of 16 mesh/cm (40 mesh/in.) brass or stainless mesh, melted into the plastic (figure 20). Alternatively the beekeeper may drill several small (1.5 mm) holes in the centre of the lid, or drill several 1 cm holes or a single large hole and melt a piece of mesh into the plastic around the holes with a hot iron. Once the pail is filled and the lid replaced, the pail is inverted over the hole in the inner cover. Some syrup will drip out until a partial vacuum is formed inside the pail; this syrup should not be allowed to drip on the ground as any exposed syrup in the bee yard may incite robbing. The recessed lid will allow space for bees to come up and take the syrup.

Some leakage may occur from the feeder pail when heated by the sun, causing expansion of the air within the pail. This may be prevented by placing a super and an outer cover on the hive around the pail. Hot syrup tends to run out of inverted feeder pails so syrup should be cooled to room temperature before feeding.

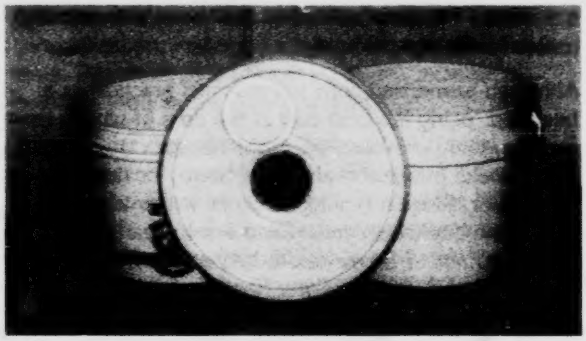


FIGURE 20.
Pail feeder showing pail and screened lid with filling cap.

In addition, hot syrup will denature antibiotics added for bee disease prevention and control. However, during cold weather bees will take warm syrup much more quickly than cold syrup, so undue cooling is not necessary.

Feeder pails should be stored in a cool, dark place when not in use. If handled roughly, especially when cold, the lid and rim of the pail will tend to crack. If properly cared for the pail will have a life of several years.

Jars with holes punched in the screw-type lids may be used as hive top feeders. Again, the larger the jar the better, and the jar should be protected from direct sunlight, for the reasons mentioned below.

4. Boardman feeder — This feeder is made up of a wooden block which holds a canning jar and can be inserted into the entrance of the hive (figure 21). It allows the beekeeper to see at a glance how much syrup is left to a colony. However, there are several disadvantages to this type of feeder: as with feeder pails, direct sun may cause leakage; the syrup does not receive any heat from the cluster and may freeze during cold weather; in cold weather bees will not leave the cluster to come to the hive entrance; and exposure of antibiotics in the syrup to direct sunlight will cause almost immediate breakdown of the antibiotics. Also, colonies which need to be fed in the fall usually require more than can be given in a container of this size unless the beekeeper is committed to replenishing the syrup as soon as the jar is empty.

5. Outdoor feeding — To save time some commercial beekeepers feed each bee yard with a drum of sugar syrup sitting amongst the colonies. The practice is not recommended for several reasons: as mentioned above, exposing sugar syrup to hungry colonies incites robbing behavior. Robbing puts each colony on the defensive and a yard full of defensive colonies is not a

pleasant place in which to work. Robbing is also one means of spreading disease among colonies.

Another negative aspect of outdoor feeding is that the strong colonies with a greater foraging force tend to collect more feed, whereas the weak colonies with few foragers tend not to get enough. Thus the strong get stronger and the weak get weaker, whereas the aim of the beekeeper should be to have colonies equal in strength. This practice also feeds any other colony within foraging distance, be it the beekeeper's colony or that of the neighbor.

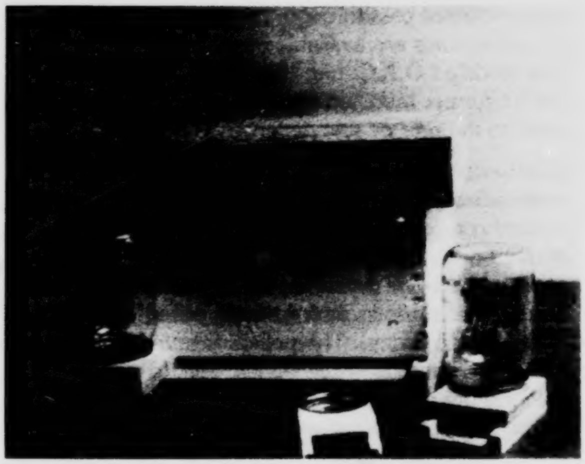


FIGURE 21.
Boardman feeders.

PROTEIN SUPPLEMENTS

Pollen is the colony's only natural source of protein and lipids (fats), and contains many vitamins and minerals essential to normal functioning of the bees. As well, pollen contains aromatic compounds which attract bees and stimulate feeding. Protein is necessary to stimulate the hypopharyngeal glands in adult worker bees and for the production of royal jelly by these glands. Protein is also necessary in the development and maintenance of adult muscles, glands and other tissues. Young adult bees normally eat pollen until they are about 10 days old, during which time they are active in feeding brood. It is estimated that colonies require between 18 and 32 kg of pollen per year.

A lack of pollen at any time during the brood production months will lead to a setback in brood-rearing and consequent decline in colony population numbers, which will in turn lead to reduced honey yields.

Traditionally spring pollen sources have always been plentiful on the prairies, the earliest flows being from willows and poplars. However, changing agricultural practices and increased land clearing have made good spring locations hard to come by in some regions.

Poor flying conditions may lead to temporary pollen shortages. The period between spring and summer nectar flows may be a pollen dearth period, when the dandelions are finishing and the canola is not yet in bloom. The feeding of protein supplements in times of pollen shortage is a management practice that should therefore be seriously considered by the beekeeper.

Pollen supplements and substitutes — Pollen supplements contain some pollen and some other protein source such as expeller-processed low-fat soybean flour, milk powder, or brewer's yeast, while pollen substitutes contain no pollen. The protein content of pollen is similar to, though somewhat less than that of soybean flour, brewer's yeast and milk powder. Bees can rear brood using these other protein sources, but the advantage in adding pollen is the attractiveness of the resulting mixture to the honeybee. Pollen substitutes may not be utilized in some instances, probably because of the lack of a feeding stimulant.

Whether mixing supplement or substitute, it is best to experiment on a small scale to find a suitable formulation before going into production. The important thing is to find the right consistency: too sloppy a mixture will drip down between the frames, while too stiff a mixture will not be utilized as readily by the bees. It might be necessary to hold back on the liquid portion or to add more dry ingredients to the mixture to correct the consistency. Supplement and substitute mixtures may be blended by hand, or with the aid of a commercial bread dough mixer or drill press.

Once protein foods are given to colonies in the early spring, a steady supply must be maintained until fresh pollen is available. Pollen substitute will be ignored once the bees are able to collect fresh pollen, but there is some indication that straight pollen patties or pollen supplement may actually decrease pollen foraging and reduce the amount of pollen brought into the hive. Feeding pollen supplement should therefore be discontinued once fresh pollen is available.

Supplement formulations — Pollen may be fed alone, mixed with sugar syrup, or mixed with other protein foods and sugar syrup. Basic proportions are as follows:

1 part pollen
2 parts hot water

5 parts granulated sugar
5 parts soybean flour (expeller-processed low fat) or other substitute

The pollen must be mixed with the water to dissolve the pollen pellets. Add the sugar and stir until dissolved, then add the soybean flour (brewer's yeast or other suitable dry material) and mix into a dough. The relative proportion of the pollen may be increased.

Substitute formulations — Pollen substitutes may be fed to colonies as either a dry mixture or a moist patty. The dry mixture, with or without sugar, may be fed inside the hive, either on top of the inner cover or in a frame feeder, or outside the hive in containers protected from the rain. Bees seem to dive into the mixture head first; in any case they become dusted with the mixtures as they collect it with their mandibles and are subsequently quite easy to pick out both in the air and in the hive. Because soybean flour and brewer's yeast are not very attractive to honey bees they may be mixed with an equal or greater weight of sugar or a 2:1 sugar syrup. One formulation is as follows:

3 parts soybean flour
2 parts brewer's yeast
2:1 sugar syrup

Pollen supplements and substitutes may either be packed into pails or made into patties for subsequent feeding. To form the patties a sheet of wax paper may be used, placing the required amount of dough towards one end and folding the other end over, flattening with the hands or a rolling pin. Another method is to form a loaf-like shape of the dough, chill it, and cut it into 500 g slices, placing these between wax paper sheets. Plastic bags may also be used. Patties may be made in advance and frozen until required.

Pollen and disease transmission — If pollen is collected from diseased colonies it will then act as a reservoir of infection for such diseases as American and European foulbrood and chalkbrood. Oxytetracycline should be added to protein supplement mixtures as a protective measure against the foulbrood diseases. However, there is no antibiotic available to protect honey bees from chalkbrood. Thus pollen should be collected from disease-free colonies only, including the foulbrood diseases, chalkbrood and sacbrood.

Caution — Antibiotics must never be fed to colonies while trapping pollen for human consumption. This can lead to pollen contamination especially if bottom mounted traps are used.

Harvesting and storing pollen — There are many pollen trap designs available but all involve the same basic principles: the bees must pass through a screen with 5 mm spaces (5 mesh), which knocks the pollen pellets from their legs; the pollen pellets then gather below another screen with 3 or 4 mm spaces (6-8 mesh), which keeps the bees out.

Variations in pollen trap designs include differences in location, size, and method of installation. Traps may fit over the front entrance or between the bottom board and first brood chamber. Some traps are designed to keep hive debris and pollen pellets separate. Some traps include cone-shaped drone escapes, as the drones cannot pass through the double screen. Plans for pollen traps are available from the apiculture office. The modified O.A.C. trap (figure 22) is popular and can be further modified to have the pollen drawer open to the rear or side depending on preference.

Whichever design is used, the pollen trap must be weatherproof to protect the pollen. The pollen-collecting container is of wood, often with the bottom of cloth or copper screening to prevent condensation and mold. Pollen should be collected from strong disease-free colonies during strong pollen flows (more than 100 g per day). The pollen collected from one colony over a season can be fed back to up to 50 colonies the next spring in pollen supplement patties. Some honey bee colonies appear to have a genetic predisposition towards collecting pollen, and the beekeeper who intends to trap pollen each year may consider retaining some pollen-collecting stock for this purpose. Pollen should be removed from the traps on a regular basis and daily during heavy pollen flows or wet weather. Hive equipment must be bee-tight and other entrances closed, as bees are adept at finding alternate routes into the hive so as to avoid passing through the double screen.

If left on the hives throughout the brood-rearing period pollen traps may cause some reduction in brood-rearing and honey yield. Front-entrance traps may cause congestion problems during the nectar flow, and may interfere with ventilation during hot weather. The double screen may be removed in and out of the hive as well as some replenishment of pollen stores. Removal of pollen traps before the end of the summer will allow some pollen storage for use the following year.

Once collected, pollen must be stored correctly to retain its attractive and nutritive qualities. The best method of storage is to bag and freeze the pollen immediately after collection. Pollen stored in the deep freeze will keep its nutritional value for several years.

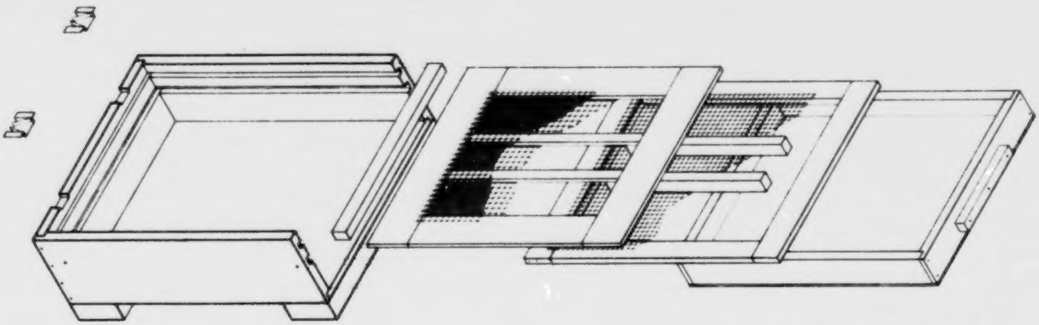


FIGURE 22.
Modified O.A.C. trap.

Another method of storage is to mix pollen with half its weight of dry sugar, pack the mixture into containers and cover with a layer of sugar before sealing. This pollen mixture may be stored at room temperature and retains its nutritional value fairly well. Pollen may be air-dried in a warm room until the pellets are hard and then stored in sealed containers in a cool, dry place. The nutritional value of air-dried pollen decreases with time, and it should be used within two years.

SUPPLYING WATER TO HONEY BEE COLONIES

Since honey bees do not store water as they do pollen and honey, a continuous supply of water is important to the proper functioning of the honey bee colony. Water is used to liquefy granulated honey and to dilute honey and sugar syrup for feeding to larvae. Without sufficient water, brood rearing is curtailed. Bees collect water every day, and generally visit the nearest source for their supply. They may become a nuisance around stock watering troughs, outdoors faucets and swimming pools if water cannot be found closer to the hive. If water can be found nearby then less energy is expended by the colony and more foraging time is available for nectar and pollen collection. In the winter bees use condensed water gathered on the sides and top of the hive.

Natural water sources such as clean puddles, ditches and small ponds and streams are suitable. If no such source is nearby, drums or smaller containers may be placed in the bee yard and filled with water and flotation devices such as sticks, boards, and dried twigs upon which the bees may alight. Alternative devices include corrugated iron or plastic sheets sloped into a gutter or trough to collect rain water, or a cistern to collect rain water from the roof of an adjacent building. Syrup feeders can be used to keep a continual supply of water in each colony, if desired. Some beekeepers add salt to their bees' water supply, which seems to be attractive to bees at less than 1 per cent concentration but which is repellent at greater concentrations.

V. SPRING MANAGEMENT

SELECTING AN APIARY SITE

A good apiary site is important to help honey bee colonies develop to their maximum populations in time for the main nectar flows. Factors to consider when selecting an apiary site include the following:

1. **Hives should be sheltered from prevailing winds, especially at ground level, with southern exposure to take advantage of the sunshine.**
2. **All-weather accessibility is important to prevent any delays in hive management; special attention must be paid to the possibility of flooding.**
3. **Grassy or sandy areas retain warmth better than tilled ground and are therefore preferred. Vegetation in front of the hive entrances should be controlled by mowing or by applying Roundup® at a rate of 75-125 mL in 6.5 L of water, after the landowner has been consulted.**

4. Sources of spring nectar and pollen (willow, maple, cottonwood and dandelion) should be nearby to reduce the supplemental feeding required.
5. If no natural sources of water are nearby, watering stations should be placed in the apiary: otherwise bees may forage for water at livestock watering troughs and irritate both livestock and farmers.
6. If the sites are to be used throughout the summer, adequate bee forage must be available. As bees readily forage up to 3.2 km (2 miles), apiaries should be located near the centres of areas having a variety of nectar-producing crops such as alfalfa, clover, canola, sunflower and buckwheat. Strong colonies should be moved to those areas having early summer nectar flows: weaker colonies should be moved to later flow areas.
7. Sites should be large enough to accommodate the desired number of colonies without crowding.
8. Sites which may be prone to molestation by livestock, bears and humans should be avoided wherever possible. Electrified fences may be used to protect apiaries from bear damage. Further information on these fences may be obtained from your local conservation or fish and wildlife officer or by contacting the Natural Resources or Fish and Wildlife office in your province.
9. If several apiary sites are used, it is helpful to locate them so that both travel time and distance are minimized. Attempt to take advantage of various soil types, crop situations and regions of different rainfall potentials, as areas can vary greatly from year to year.
10. ETHICS! Do not place an apiary too close to other beekeepers' apiaries. Try to maintain a minimum distance of 1.6 km (1 mile) between apiaries to reduce the risk of disease transmission and to help you and your neighbour obtain an equitable honey crop.

APIARY LAYOUT

The minimization of drift within an apiary site is an important consideration when arranging hives. When certain colonies receive large numbers of bees from other colonies within the apiary, problems such as swarming, early supering and disease transmission may occur. These situations will result in a loss of honey production within that apiary. Early drifting can be especially detrimental to newly hived packages.

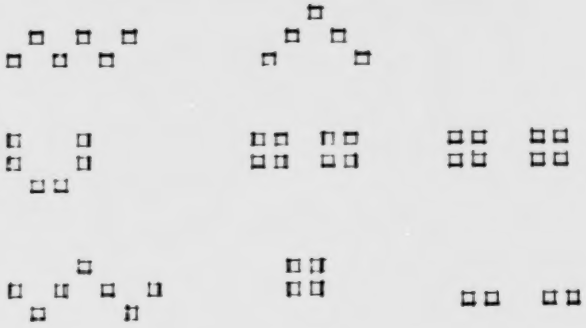
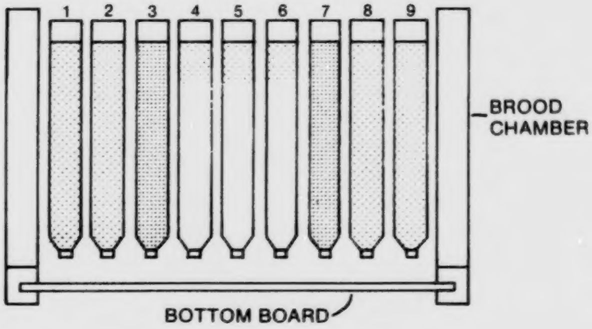


FIGURE 23.
Apiary layouts.

To help reduce drifting and to ensure evenly-populated hives in an apiary, the following methods may be used:

1. Use irregular, non-repetitive hive layouts, facing the hive entrances in different directions, as illustrated in figure 23. Hives should be spaced 1-2 m apart within each layout for best results. The use of 4 hive and 2 hive pallets effectively reduces drifting in addition to other benefits.
2. Use colored hive bodies or colored strips above the hive entrances. Colors such as black, white, yellow and blue are "seen" by bees.
3. Use existing landmarks such as trees, bushes, fences as orientation cues. When choosing a hive layout, the beekeeper should note the presence or absence of windbreaks, lines of bee flight, and accessibility for equipment to be used (trucks, forklifts, etc.).



Frames 1, 2, 8, 9 - Honey 4 frames
Frames 3, 7 - Pollen
Frames 4, 5, 6 - 75% empty but ringed with honey and/or pollen.

FIGURE 24.
Arrangement of food stores in first brood chamber prior to installing bees.

FIELD RECORDS

Good field records of weather, dates of nectar and pollen flows, colony condition and management are of real advantage to the beekeeper. Over the years these records allow an evaluation of apiary sites: which sites, for example, are prone to stress-related maladies such as chalkbrood; when early flows can be expected; which sites are better for wintering. Such records also help the beekeeper to anticipate steps in colony management. Records of individual colony performance are helpful when specific problems are present or when the beekeeper wishes to rear queens from his or her best stock.

PACKAGE BEES

Packages should be ordered in January through a commercial beekeeper, a local bee club, or directly from a reputable package bee producer. Many commercial beekeepers truck their own packages or have trucking arrangements. Although the recommendation has been made that packages should be installed nine to ten weeks before the main nectar flow is expected, there appears to be a trend towards earlier arrival and installation dates. Time of arrival is largely up to the beekeeper's preference and experience. If early April is cold early packages may not build up any faster than later packages; however, if early April is warm and sunny then early packages will have the jump on later packages. Generally, packages should arrive no later than the second week of April.

Most package beekeepers order packages containing 0.9 kg (2 lb) of bees, but some order packages with 1.4 kg (3 lb) or even 1.8 kg (4 lb) of bees. The more bees the better, all other things being equal. The larger population is less fragile and less care may be needed, although there are seasons where the smaller packages may do just as well. Again, package size is a matter of personal preference and intended management. If two queen colonies are planned, larger packages may be better at the start. The number of bees per kilogram can vary depending on the engorgement of the bees when packages are made up. The more sugar syrup, honey or nectar in or on the bees, the more each bee weighs, and the smaller the number of bees in the package. An extra allowance of bees should be added by the package producer to the final package weight to make up for this variability.

Brood boxes should be prepared and the single-storey hives should be placed at the apiary site before the packages arrive. Each brood box contains nine frames of good brood combs, or ten frames if foundation is being used. Frames 1, 2, 8 and 9 should be full of honey (Figure 24), frames 3 and 7 should be full of pollen, and frames 4, 5, and 6 should have empty areas ringed with pollen and/or honey. A frame feeder may replace frame 2 or 8 (1 or 9). If honey is not available sugar syrup must be supplied to the bees immediately upon hiving, especially if they are hived on foundation. Protein supplement should be given if neither stored nor fresh pollen is available. Blocks reducing the entrance to 2-4 cm should be on the hive entrances.

When the bees arrive at their destination they have been in the packages for at least three days. To minimize further stress they should be handled gently and hived as soon as possible. The bees are much less vulnerable to environmental changes in a well-provisioned hive than in a package. If storing is necessary, packages should be kept in a dark room at about 15°C, and may be fed by spraying or sprinkling the screens with warm 1:1 sugar syrup to supply water and carbohydrates for energy. One should avoid using a paint brush to apply syrup to the screens as this will damage the bees' tongues. Hiving should be done on a cool, cloudy day or in late afternoon and evening, so that the bees have a night to settle in and do not immediately fly away and get lost or drift to another hive.

The generally accepted method of getting the bees from package to hive is as follows: frames 4, 5 and 6 are removed and leaned against the brood box. The package is sharply rapped by bringing it down on the brood box or other available object, causing the bees to drop in a heap from around the feeder can. The can is removed, the queen in her cage is removed and placed in a pocket for warmth, and the bees are shaken into the hive. Two or three sharp raps and shakes should roll all of the bees out of the package.

The queen should be checked quickly before releasing, for presence of legs and wings and absence of damage. She may then be released directly into the cluster (direct release method) by pouring some syrup on on her and immediately draining it off, holding the queen cage just above the bees and prying the screen away, watching as she falls into the mass of bees. Queens which have been confined to queen mailing cages tend to be a bit flighty, and syruping the queen prevents her from taking flight when released. The three frames are gently replaced without spacing, and the lid replaced. Alternatively, prior to shaking the bees into the hive the queen cage, cork removed, may be placed on the bottom board screen side up and the bees shaken on top. After the bees are added, the frames and cover are replaced and the cage removed at a later date. If the weather is warm or the bees are agitated, immediately prior to hiving, each package may be sprayed with or dunked in water to slow down and prevent immediate flight.

The queen may be released more slowly by using one of the slow release methods outlined in section 11. Some beekeepers feel that a slow release allows the bees to calm down and settle in before the queen is freed, preventing any antagonistic action towards her at the time of hiving. Other beekeepers feel that a day or more of egg-laying is wasted with a slow release.

An alternative method of hiving package bees is to shake the bees directly on top of the frames, syruping and releasing the queen onto the cluster and covering the cluster with a piece of sacking until the bees work their way down between the frames. When finished hiving all the packages in the yard, the beekeeper then makes another round, placing the outer covers on top of the sacking. This method appears to work fairly well, especially in sub-zero weather.

Once hived, bees can be given medicated sugar syrup for protection against disease and for stimulative purposes, even if feed is not otherwise required.

Five to seven days after packages have been hived (table 4) the colonies are quickly checked for laying queens by checking a centre frame for the presence and pattern of eggs. If eggs are present and in a good pattern with one per cell the queen is doing well and need not be seen. Frames are spaced and the lid replaced with a minimum of disturbance. If no eggs are present the queen should be found. An apparently healthy queen may be left alone, and the hive marked for later reinspection. If the queen is injured or missing (perhaps dead on the bottom board or in front of the hive entrance) a new queen must be introduced using a slow-release method. If not already done, antibiotics and sugar syrup may be given to each colony.

The second check is made 10-14 days after the first check. At this time the brood pattern is again examined on a frame or two, and disease and pest problems are looked for. Colony food stores are checked and supplemented if required. Oxytetracycline should be given again, as outlined in the appendix. If the brood pattern is spotty or shows bullet-shaped cappings or if no brood or only capped brood is present, the queen could be diseased, poorly mated or a drone layer and should be replaced. Any supersedure cells must be crushed if the beekeeper plans to requeen, or the replacement queen may not be accepted. A colony with no brood at all has likely been queenless since hiving; if sufficient bees are present the colony may be requeened, or if numbers have dwindled each frame of bees may be shaken in front of another colony needing additional population.

WINTERED COLONIES — EARLY SPRING

Much of the early spring management of wintered colonies depends on the quality of the previous fall management and the method of wintering (see section 10). Overwintering colonies begin rearing brood in January or February and honey and pollen consumption increase dramatically with increased brood-rearing. An early spring check is necessary to determine the amount and availability of food stores. This check should be done on outdoor colonies in early March or as early as possible, on a warm sunny day with no wind. The top covering and insulation are removed, the inner cover gently pried up and a little smoke used to keep the bees calm. It is not advisable to disturb the bees by pulling frames from within the cluster. By looking down between frames capped honey can be seen. The colony should have from four to six honey frames in contact with the cluster; outer honey frames may be placed next to the cluster if necessary. Protein supplement may be given, and extra honey frames or an inner feeder of warm 2:1 sugar syrup may be placed next to the cluster if honey stores are low. The colony should be closed up and insulation replaced with as little disturbance as possible. Dead colonies should either be removed or closed up to prevent robbing. Colonies should be checked again for food stores in early April, the protein supplement replenished and honey or syrup given as necessary. Colonies wintered indoors can be moved outside in April, depending on the weather and the beekeeper's preference, and may be fed at that time with pails or inner feeders of 2:1 sugar syrup and antibiotics. Once the weather has warmed up and the pollen and nectar flows are in full swing, winter wraps may be removed from colonies wintered outdoors; generally this will be done in the first half of May. At this time, colonies wintered both indoors and out are subject to an extensive check. Brood chambers are removed from the bottom board, which must be scraped and cleaned of all accumulated debris and dead bees.

Brood chambers may be reversed at this time (figure 25) if the upper brood chamber is full of bees and the cluster extends into the lower brood box. Weaker colonies may be left in two chambers or reduced to a single box depending on the number of bees.

TABLE 4
BEEKEEPING SEQUENCES AND CHECK LIST

VISIT	TIME AFTER HIVING (Package bees)	PURPOSE	SYMPTOMS	SOLUTION
1	5 – 7 days	QUEEN CHECK Queen right	Eggs (Do not look for queen)	Close hive
		Queenless	No eggs Roaring sound Bees agitated	Requeen or check again in 3 days
		AFB-EFB prevention		Feed antibiotics
2	3 weeks	QUEEN CHECK Queen right	Brood in all stages	OK
		Queenless	See visit 1	Requeen or unite
		Drone layer	Convex cappings	Requeen or unite
		Supersedure	Queen cell(s) on face of comb	Destroy queen cell(s) and requeen or unite
		Laying workers	Many eggs/cell Eggs on cell wall No queen	Kill colony or dump bees
		Multiple laying queen	Several eggs in bottom of cells	OK
		AFB-EFB prevention		Feed antibiotics
3	4 – 6 weeks	QUEEN CHECK	See visits 1 and 2	
		BROOD PATTERN CHECK Good	Frames of brood of uniform age with few cells empty	OK
		Poor	Spotty appearance, brood of different sizes; many cells empty	Requeen or unite
		FOOD CHECK Lack of honey	Empty cells Starved bees Bees running over frames "shaking"	Feed syrup or add frames of honey
		Lack of pollen	Presence of eggs and emerging adults but no brood	Feed pollen supplement or substitute
		AFB-EFB prevention		Feed antibiotics
		SPACE CHECK Space required	6-8 frames of brood and bees present	Add 2nd brood super
		Space not required	less than 6 frames of brood and bees	Check for space in 1 week. Check that queen, stores OK and disease-free
4 and others	Every 9 – 10 days after visit 3	FOOD CHECK	See visit 3	Feed syrup or frames of honey
		SWARM PREVENTION Preswarming-crowded	Queen honeybound No space for eggs "Wall-to-wall bees"	Reverse hive bodies and add a super Provide ventilation
		Swarming initiated	Queen cells on sides and bottom of frames	Remove queen cells every 9-10 days, add supers where needed and reverse Provide space and ventilation Demaree
		SUPERING	— Add 1st honey super prior to expected honeyflow — Add others as needed 1 or 2 at a time	
		AFB-EFB prevention		Cease all medication by June 14

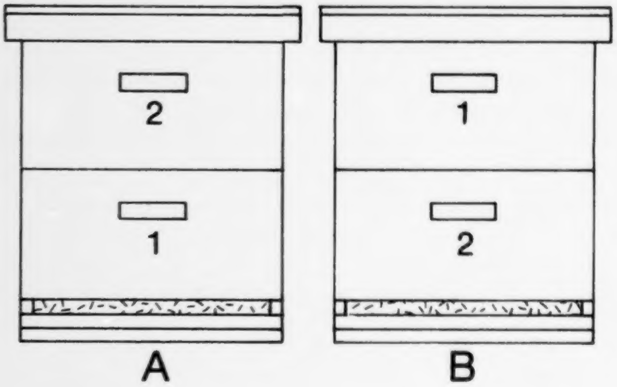


FIGURE 25.
Reversing brood chambers. A: prior to reversing. B: after reversing.

At the same time colonies are assessed for queen problems, disease symptoms, food stores, and strength. A strong wintered colony will have from four to seven kilograms of bees (covering 9-11 frames) and five or more frames of brood. Dead colonies should be cleaned out and removed from the apiary. Very weak and queenless colonies and colonies with drone-laying queens may be united with medium strength colonies, remembering to pinch off the poorer queen first. The queen's performance can be assessed by checking one or two frames for brood pattern, and symptoms of brood disease can also be checked for. Food stores are assessed, and 2:1 syrup is given to replace depleted stores and stimulate brood-rearing. Oxytetracycline should be given in the syrup or in icing sugar and fumagillin may also be fed in the syrup.

CHECKING COLONIES

Regular checks should be continued through May and June at 10-day intervals. These checks are done with several questions in mind: How does the brood pattern look? Is there brood in all stages? Are there symptoms of any disease? Are pests such as ants or skunks present? Does the colony have enough stored honey and pollen? Does it require space for bees, brood and food storage? Are there swarm cells? The beekeeper must assess each colony, decide on its needs and fulfill those needs as much as possible, and deal with any problems. At the same time the general condition of the apiary is noted, including duration of the spring flow and likelihood of dearth periods. Each colony should be fed oxytetracycline every 10-14 days until the first week in June.

While checking the brood chambers, especially of wintered colonies, any broken or misshapen combs or combs with large areas of drone comb should be culled and replaced with good quality worker combs. Culled combs may be marked and placed on the outside edges of the second brood chamber or the third box to allow brood to hatch out, if desired. They may then be removed when honey is taken for extraction, and melted down or destroyed. Bottom boards, frames and hive covers should be repaired or replaced when broken or rotting. Many beekeepers carry hammer and nails in their trucks for equipment repair in the bee yard.

If at any time during these checks a robbing situation develops the beekeeper should finish the colony being checked, close it up and leave the yard, rather than making the situation worse by continuing to open hives.

FEEDING COLONIES

Feeding both sugar syrup and protein supplement may be required at times through the late spring and early summer (see section 4). If the spring nectar flow is minor or of short duration, or if there are periods of inclement weather, colonies may easily become short of honey and pollen during the rapid buildup period preceding the main nectar flow. Feeding of sugar syrup should cease two weeks before the onset of the main nectar flow to avoid contamination of the honey.

REQUEENING WINTERED COLONIES

If the beekeeper winters his or her colonies each year some schedule of requeening every one or two years is advisable. If commercially-produced queens from the south are used requeening may be done at any time during spring or early summer. If queens are to be reared by the beekeeper or purchased domestically the time of requeening depends on when new queens are available, but will usually be just prior to or during the main nectar flow. Methods of requeening are covered in section 11.

EQUALIZING COLONY STRENGTH

Equalizing serves two purposes: it boost weak colonies and it slows down the growth of strong colonies, so that all colonies in the apiary reach their peak in population just as the main nectar flow is beginning. Very weak and queenless colonies may be united with colonies of medium strength or placed above another colony to make a two-queen unit. To boost a weaker colony one or two frames of capped brood are taken from a stronger colony, the bees are shaken off and the frames checked for disease, and the frames given to the weaker colony. Transfer of open brood is not recommended, as it merely makes more work for the weaker colony, instead of supplying it with more bees to help expand the brood nest. Caution is advised when equalizing, as exchanging diseased frames spreads the malady from one colony to another. As an alternative method, weak and strong colonies may be switched in position so that the weak colony receives the incoming foragers of the strong colony. However, strong colonies should never be ruined to provide for the weak.

UNITING COLONIES

Very weak colonies are often the result of a poor or failing queen. Rather than attempting to requeen such colonies and nurse them back to strength, many beekeepers merely unite them with stronger colonies. If worker brood is present uniting may be accomplished as follows: the failing queen is pinched off and the weak colony is checked for queen cells, which are removed. A sheet of newspaper is placed over the upper brood chamber of a medium or strong colony, two or three slits made in the paper with the hive tool, and the weak colony placed on top. The bees will gradually chew through the newspaper and colony scents will intermingle as the scent of the weak colony fades, uniting the two colonies with no antagonism.

Alternatively, the beekeeper may shake the bees off the weak colony's brood frames and add these frames to the brood nest of a stronger colony. Bees may be shaken in front of other colonies, into which they will gradually find their way.

If no brood is present in a weak colony the bees are shaken off each frame in front of another colony. Any extra honey and pollen frames may be given to colonies in need of food stores.

Before uniting colonies the weak colony should be checked carefully for evidence of any brood disease, as diseases can be spread by both brood frames and adult bees.

DIVIDING COLONIES

Dividing strong wintered colonies is one method of slowing their buildup while increasing colony numbers, either to make up winter losses or to expand the beekeeping operation. In order not to decimate the parent colony populations it is generally better to make one new colony from every two parent colonies, or two new colonies from every three parents, rather than dividing each colony into two. Parent colonies should never be reduced so much that they will not make a honey crop themselves.

Queens for the expected number of divisions should be ordered ahead of time to be on hand sometime in May, depending on the spring weather and on the condition of the overwintered colonies. Divisions are made once the weather has warmed up and the chances for subzero temperatures are lessened. Dividing too early exposes the new divisions to the risk of chilling should the weather turn cold, while dividing late does not allow adequate buildup to a productive unit for the main nectar flow. The first offspring from the new queens will be foraging about six weeks hence, so the expected dates of the major nectar flow must be kept in mind when making divisons. Later splits may be made more strong to allow for a shorter buildup period.

A warm, sunny day with no wind is best for this work. Queens and brood chambers with bottom boards and covers for the expected number of divisions are brought to the apiary. Brood chambers should be made up with honey and pollen frames as for packages, if possible; an inner feeder of warm 2:1 sugar syrup may take the place of one frame. The queen in each parent colony is found and placed to one side. One or more frames of capped brood and adhering bees are taken from each parent colony checked for disease, and placed in the new brood chamber. A frame of honey and pollen may also be transferred if parents have a surplus. The new division ends up with three or four frames of bees and brood which are mainly capped. Parent colonies receive empty combs and their brood nests are consolidated. Two or three frames of extra bees may be shaken into the division to strengthen it. These bees will make up for field bees which fly back to the parent colonies if divisions are left in the parent yard. A new queen is placed in the division in her cage, after checking her over and removing the attendant bees. A slow-release method is employed (see section 11).

If the divisions are to be moved to a new location queen acceptance may be better if requeening is done after the move.

The new divisions should be moved to another apiary site if at all possible, to avoid the problem of drift back to parent colonies. If this is not possible, the divisions should be set down away from the parent colonies and oriented in a different direction. The reduced entrances should be loosely plugged with grass to slow the flight of the bees and allow them to orient to their new location.

Alternatively, the new division may be temporarily placed on top of one of the parent colonies over a solid inner cover, with a 5 cm entrance in the rim facing towards the back, loosely plugged with grass. Thus the division can take advantage of the heat from the colony below until it gains some strength. It may then be set down when the yard is supered. Robbing of these small colonies can be a problem, so equipment should be bee-tight and entrance size reduced.

Divisions may also be made without searching for the queen. This method is useful when many divisions are to be made or when making a number of two-queen hives. The parent hive is inspected and three frames of capped brood are procured. The bees are shaken off these frames and placed in a brood chamber with supporting frames of honey pollen and empty comb. The removed frames from the parent hive are replaced with empty comb. A queen excluder is then placed on the parent hive and the division is placed on top. The bees will quickly move up to cover the brood frames in the division but the queen will not be able to pass through the excluder. In 30 minutes or so the division can be placed on its own bottom board and possibly moved to another apiary or the excluder can be replaced with a solid inner cover as above, if two queening is the object. A new queen is then introduced as before.

These new divisions are useful in requeening strong colonies which go queenless before the main nectar flow; a proven young queen which is already laying is then available. The division may be united to the queenless colony using the newspaper method. If divisions are made solely to establish queens for subsequent requeening of wintered colonies they may be made up later on, towards the beginning of June (see section 11).

An alternate method of increasing colony numbers for next year is to make up nuclei (nucs) which are not intended to produce a honey crop this season, but which have time to build up to good wintering strength by September. Nucs are made up in the first part of June, prior to June 15, and timing is critical to their successful buildup. Two or three frames of capped and emerging brood and adhering bees are placed in a separate brood chamber and given a queen; the nuc is then set aside from the parent colony and is fed syrup and protein supplements, if needed. The hive equipment should be bee-tight and an entrance reducer in place to prevent robbing. By September these nucs will have built up to a colony filling two brood chambers, and they may even produce surplus honey some years. This method allows the new queens to be of one's own stock or of locally-purchased queens or queen cells.

If colonies are wintered indoors these nucs may be made at the end of June, thus taking advantage of brood which will not be old enough to be collecting much nectar during the main flow. Nucs made up at this time may not build up to more than one brood chamber in strength and may not be strong enough to winter well outdoors. However, both nucs and single storey colonies can be successfully wintered indoors.

MOVING TO SUMMER APIARY SITES

If the spring yards are not suitable for summer as well, summer sites should be found well before the main nectar flow is expected. The beekeeper should aim for a good uniform average from year to year, taking advantage of variations in weather, soil and crop conditions in different locations. Field records from previous years will indicate which areas traditionally yield well and when flows can be expected. Areas can change drastically from year to year, however, so once the crops are planted an area may be assessed in terms of what nectar-yielding crops will be present. Assessment can be done by road, by conversation with growers, and by air. Summer site requirements are essentially the same as those for spring sites: all-weather accessibility for vehicles, some shelter from wind, enough room for all colonies, arrangement of sites to minimize travel time, and of course, water supply and good summer nectar flows. Some may be beneficial during the heat of the afternoon, although shade makes the use of fume boards difficult. Yards should not be subject to visits from cattle or other domestic animals or bears. Locations away from main roads may give some protection against problems with vandalism and thievery, as well as protecting bees from road traffic (and motorists from squashed bees on their windshields).

Honey bees forage up to 3.2 km from the hive with no significant loss in honey yield so if two crops are located 5 km apart the summer yard should be located halfway between them rather than beside one or the other.

Package colonies should be moved while still in one brood chamber, if at all possible. Once seconds and supers have been added the colonies become quite heavy and awkward to handle. Depending on accessibility of summer sites, numbers of hives to be moved and the duration of the spring flow, colonies are generally moved in May. Moving is done preferably at dusk or at night when the bees are all in the hives and the air temperature is lower. Entrance and top screens are not required for short moves at night.

Many beekeepers permanently fasten bottom boards to the first brood chambers with two hive staples on each side, slanting in opposite directions. While this is helpful for moving, permanent fastening makes reversing brood chambers and cleaning bottom boards difficult. Another means of stabilizing the first brood chamber on the bottom board is with nails protruding through the bottom board rim into the brood box. While preventing lateral movement, this method does allow the removal of the brood chamber from the bottom board with the aid of a hive tool.

Before lifting the hives several puffs of smoke are directed into the entrance to keep the bees from flying out. Without smoke the beekeeper will have many angry bees to contend with. Hives should be loaded with frames parallel to the truck so that rocking is minimized. If frame spacers or self-spacing frames are used there should be no problems with frames sliding together or falling from the frame rests. Otherwise, frames 4, 5 and 6 may be fastened in place with nails driven through the hand-holds (left protruding for easy removal). Hives are tied in place on the truck to avoid shifting in transit. Once unloaded with the aid of the smoker at the summer apiary site, hive entrances may be lightly stuffed with grass to slow down and confuse the foragers, so that they have a chance to reorient to the new location.

If colonies are moved less than 3-5 km field bees often return to the old site rather than becoming reoriented to their new location. Colonies should therefore be moved more than 5 km.

When only one or two colonies are to be moved and a truck is unavailable, they may be moved in a station wagon or van. In this case staples or strapping and entrance screens are definitely a good idea. Entrance screens are of stiff mesh with 4 mm spaces or smaller; the screen is the length of the hive entrance and about twice the width, folded in half so that when the fold is pushed into the entrance the screen holds itself in place. All cracks between supers should be plugged or taped.

For daytime moves in hot weather top screens allow ventilation and clustering space for the bees. These are boxes about 10 cm in depth, screened on the top, with cross supports on which the cluster may cling.

Hives to be moved a short distance, across the back garden, for example, should be moved a little each day so that returning foragers can find their home.

APIARY MAINTENANCE

Although long grass around the hives does help to shelter them and retain heat in early spring, it will also interfere with later ventilation and bee flight to and from the field. Vegetation in front of each hive should therefore be controlled so that the bees have easy access to the hive entrance. Mats of cardboard, sugar sacks cut in half, tar paper and the like may be placed in front of each hive and anchored under the bottom board. Alternatively, vegetation may be mowed or treated with herbicide around each hive. Herbicides are very effective when applied to young vegetation early in the season but should not be used when the bees are flying to avoid possible toxic effects. Care must be taken when applying herbicides to other people's land.

Soil sterilants and herbicides with long residual properties are not recommended, as they may have undesirable effects on nontarget vegetation such as the trees surrounding the bee yard.

Apiary sites sprinkled with short stumps, which stay hidden in the grass to trip the beekeeper or hang the truck up, are better avoided. Dead branches and so on may be removed if obstructing apiary management. Broken frames and bits of comb should be collected and removed from the yard after each visit. Any ruts made in access roads to bee yards should be repaired, especially on land not owned by the beekeeper. Good relations with the landowner are essential if the beekeeper wishes to retain his or her apiary sites.

SPACE REQUIREMENTS AND SUPERING

Beekeepers have traditionally allowed a total of five bee boxes per hive. While this number is probably sufficient for package colonies in most regions, more boxes are needed for wintered colonies. The latter may require three brood boxes and three or four supers for a total of six or seven boxes per hive. Too few supers eventually means losses in honey production.

Package colonies with good prolific queens can generally receive second brood chambers from five to seven weeks after hiving, or in the latter half of May. They should have five or six frames of brood and from seven to nine frames of bees at this time. Seconds should contain nine dark brood combs with pollen and honey arranged in the same manner as in the first, if possible. If the bees are slow to move into the seconds one or two frames of capped brood may be placed in the centre of the second to draw them up; this baiting must be done when boxes of foundation are given. If colonies are not yet strong the seconds may be placed underneath the firsts, to provide extra space without dissipating cluster heat. Brood chambers may then be reversed as required.

Wintered colonies are generally in two brood chambers when unwrapped, which are reversed when room for upward expansion is needed. Brood chambers may need to be reversed again during May.

A third box, made up with nine empty combs, is added to each colony when there are five or six frames of brood in the second and before the second becomes plugged with honey, generally by the middle or the end of May for wintered colonies and the middle or end of June for packages. Entrance reducers can be removed from the colonies around the beginning of June. Timing varies from year to year and yard to yard, so it is important that the beekeeper check his or her colonies regularly to assess their needs.

Honey supers contain nine frames of honey comb, preferably light in color, as dark combs, while preferred by the bees, may darken the stored honey. Comb which have had one or two cycles of brood reared in them are ideal for honey storage, being light in color but strengthened by cocoon residues and propolis. Newly-drawn combs must be extracted with care, as they are easily broken.

Frame spacers are often used in brood chambers and in supers; these are frame rests with indentations to hold frames equally spaced and in place. The use of spacers saves time when supering colonies and makes the use of self-spacing frames unnecessary. Disadvantages of spacers include the loss of lateral mobility of frames when checking brood chambers, and the loss of the correct bee space between combs.

Colonies need plenty of space for bees to cluster, for wax-builders to hang, for temporary storage of unripe honey while it is being processed, as well as for brood rearing and storage of pollen and honey. Even more space is required under high temperatures and humidity or during an unexpectedly heavy nectar flow. If the hive becomes full of honey then there is no place to process nectar. This sets off a chain of events: the house bees which take nectar from incoming foragers have nowhere to put their loads, so they remain full and then cannot accept any more nectar. Incoming foragers then cannot unload and wander about the hive instead of going out to collect more nectar. Eventually the field force is all at home and no more nectar is being collected. At this point, even if more space is given there will be another time lag before the foragers are finally relieved of their loads and can return to the field. In regions of short, intense nectar flows the flow may well be over by this time, making the delay a costly one for the beekeeper.

When in doubt as to space requirements, more should be given. It is better to be too early and risk "stovepiping" by the queen (moving upwards through each box rather than expanding the brood nest laterally) than to be too late and risk swarming and reduced honey production.

Traditionally, supering is recommended just when the tops of the combs in the top box show whitening along the edges, signifying that the bees are producing wax and building out combs for honey storage in the top of that box. In regions such as the prairies, where nectar flows are intense and of relatively short duration, the honey production and storage requirements may get ahead of the wax building, and whitening of the combs is therefore not a reliable cue. The beekeeper must instead go on his or her assessment of colony strength and condition and observations on the course of the season, as well as the probable time lapse between visits. Experience and field records will be a great help. Generally two or more supers are added just prior to or at the beginning of the main nectar flow, and more are given as the flow progresses.

Both bottom supering and top supering are practised by beekeepers, although most commercial beekeepers prefer top supering for speed. Top supering necessitates getting the supers on before a honey barrier is formed, thus good timing is imperative. Bottom supering means far more work lifting partially-filled supers to place empty supers beneath but is necessary if the supers are plugged and the beekeeper does not wish to extract them right away. In addition, the queen may move into empty supers placed above the brood nest unless queen excluders are used.

DRAWING FOUNDATION

Each year some brood combs are lost through breakage and culling, and these combs must be replaced with good worker combs from the honey supers. To replace combs in the honey supers the beekeeper may give each colony up to nine or ten frames of foundation with no noticeable reduction in honey yield in a good year, although in a poor year it may be difficult to get colonies to draw out as much foundation. If at all possible colonies should never be given whole boxes of foundation, for such supers will act to some extent as a barrier to upwards expansion, and some colonies will show great reluctance to move into them. It is far better to intersperse foundation amongst drawn comb, beginning with three frames in the third super. If supers of foundation must be given they should contain ten frames instead of nine, because nine frames of foundation leave enough space between each pair of frames that the bees might build burr combs instead of drawing out the foundation. The bees tend to work on the centre frames first, so on each subsequent check outer frames may be rotated inwards.

Foundation will not be drawn out unless given during a nectar flow or while feeding a 2:1 sugar syrup. Otherwise the bees will tend to ignore or chew holes in the foundation sheets.

USE OF QUEEN EXCLUDERS

Queen excluders are often used between the second brood chamber and the honey supers, to keep the queen from entering the honey supers. They are a necessary piece of equipment in two-queen systems. Handled properly they are a useful piece of equipment. Handled improperly, they are as effective as an inner cover in keeping the colony from expanding upwards. The third box, when placed above a queen excluder, must be given before the second is plugged with honey. Drawn combs in the third box will help to entice the bees up. Placing one or two frames of emerging brood and adhering bees (checking first for the queen) in the third is another way of drawing workers through the excluder, providing that the weather does not turn cold with resultant chilling of the brood. A box of foundation must never be placed directly above a queen excluder. This constitutes a double barrier and the colony may swarm instead of expanding upwards.

TWO QUEEN COLONIES

While there are probably as many variations in making up two-queen colonies as there are beekeepers, the aim remains the same for all systems: to develop extremely large populations and to maintain high colony morale for the main nectar flow. Two queens produce more bees than does one queen. The greater the colony population the greater the ratio of field bees to house bees, and therefore the greater the colony's foraging efficiency. Thus, if managed properly, two-queen colonies produce more honey than single-queen colonies.

Other advantages of two-queen systems are in swarm control and in requeening of wintered colonies. As well, extra laying queens are always on hand for those colonies which have queen problems during the spring and summer.

The disadvantages of two-queen systems include the increased time, labor and equipment costs per colony as well as the cost of the extra queens. Two-queen colonies are quite labor-intensive and require precise timing and good management. In addition, they often reach a height of nine or ten supers and are difficult to manipulate. It is essential that the hives be on solid footing and kept level to avoid tipping. As queen excluders are used throughout the nectar flow, fume boards will not be as effective in removing honey and the use of bee-escape boards or bee-blowers may be necessary.

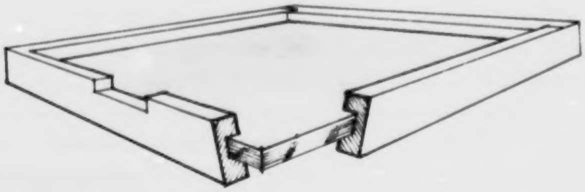


FIGURE 26.
Solid division board used in initial step in making up double queen colonies. The top entrance should face the back of the hive.

Management techniques for maximum buildup are employed early to give strong colonies in May. Two-queen units are usually made up some time in May from wintered colonies and at the end of May and beginning of June from package colonies. This time will depend on colony strength and the strength and duration of the spring flow. Two-queen colonies are at their peak from eight to nine weeks after they are made up, thus two-queen package colonies will peak at a later time than two-queen wintered colonies.

When making up two-queen units, the parent colonies should be equalized by exchange of adults or capped brood, in order to bring each colony to similar strength. The original queen is placed in the bottom brood chamber with the younger brood, food stores and empty comb. If the original queen is to be confined to one chamber an excluder is placed over the bottom chamber. One or two empty brood chambers or supers may be placed in the second and third positions with a division board atop the supers. The division board (figure 26) is generally an inner cover with all the feeding holes completely blocked, turned so that the entrance is in the upper rim and facing in the opposite direction from the lower entrance. This initial complete separation is necessary, otherwise the odor of the first queen remains throughout the colony and may prevent acceptance of the second queen. The capped brood and plenty of honey are placed in the brood chamber in the third position, and two or three frames of extra bees shaken in to make up for subsequent drifting back to the lower entrance. A new queen is given to the upper unit using a slow release method. The lid is replaced and the upper entrance loosely blocked with fresh grass to allow time for orientation. Equipment must be bee-tight in order to avoid robbing, which will greatly reduce queen acceptance and severely weaken the top unit.

If the original queen cannot be found or if the beekeeper does not wish to search for the original queens, a queen excluder may be placed between the brood chambers and each chamber checked in four days for eggs. The chamber containing the queen is then placed on the bottom and the two-queen units made up as above.

Both units are checked a week later for laying queens and signs of swarming or supersedure. Queenless units may be requeened or reunited. Division boards of queenright colonies are replaced at this time with two-queen boards, which are essentially inner covers with an entrance in the rim and most of the wood replaced with two layers of zinc excluder material, so that air and bees move through but queens do not meet. Alternatively, division boards may be replaced with single queen excluders, using sheets of newspaper to slow the mingling of the bees and allow them to become used to both queen odors. An upper entrance is made by setting the second unit forward over the excluder. The flow of air through both units allows the mingling of each queen's odor for maximum stimulation of colony morale. Bees then move freely from one unit to another with no hostility. Usually the upper queen is given another brood chamber, while the lower queen is restricted to one. However, each queen may be given two or restricted to one, depending on the beekeeper's preference. If required, supers are provided to both units. If two brood chambers are given to either queen, periodic reversal of chambers may be needed.

The brood chambers of each unit are brought together at the beginning of the main flow, just prior to the first pull. At this time the beekeeper may either reunite the units or continue to keep them separated by means of a single excluder. Uniting the units will usually cause one queen to be killed, thereby reducing the amount of brood to be fed. If two-queen colonies are used as a method of requeening, the beekeeper may wish to search out and kill the old queen when reuniting rather than leaving it to chance. Excluders are generally left between brood chambers and honey supers for the duration of the flow, then pulled to allow freer movement. After uniting, colonies are run as single-queen colonies, with the major difference being a much higher population, greater space requirements, and higher honey yields.

SWARMING

As mentioned in section 1, swarming is the colony's means of reproducing itself, by producing new queens and dividing the worker population. Capturing swarms is one method of increasing the number of colonies in a beekeeping operation. In many countries of the world swarms are routinely hived or tempted into hives and the honey subsequently harvested. However, relying on swarms for increase has its drawbacks. Firstly, while nearly any colony will swarm given the right circumstances, the hiving of a swarm may be a perpetuation of a swarming strain rather than a selection away from swarming. Secondly, the beekeeper is not in control of making the divisions and requeening them, so the quality of the stock may suffer. Thirdly, it is the strongest colonies, which would otherwise produce a good honey crop, which do the swarming. Swarming reduces colony strength too close in time to the main nectar flow and thus decreases the productivity of that colony.

Swarming involves preparation. There is a slowdown in egg laying and foraging as the bees get into the "swarming condition." Even if the colony is prevented from actually swarming through some corrective action by the beekeeper it will be less productive as a result. Management techniques are best employed to prevent the swarming impulse from occurring rather than to attempt to control it once it has been initiated.

Swarm prevention — Paramount in swarm prevention is the supplying of adequate space when needed, not just for honey storage but for brood rearing, wax-building, pollen storage, and processing of nectar. Bees need space to sit, especially during inclement weather when the foragers are confined to the hive. Inadequate space for processing and storage of honey means that the brood nest becomes honeybound and that the queen no longer has any room for egg-laying. A queen which is not laying produces less queen substance, with the result that colony cohesion is reduced and swarming is initiated.

A failing queen also produces less queen substance, and if a supersedure is underway at this time of year the colony may issue a swarm at the same time. Colonies should be requeened regularly to help prevent both supersedure and swarming. The brood nest should be kept free of congestion caused by bees and excess food stores by reversing brood chambers and adding supers.

High temperatures and humidity, poor ventilation and air drainage are all factors contributing to development of the swarming impulse, each relating to the need for space. Space requirements per bee increase with temperature. Poor ventilation leads to high humidity when excess moisture is being evaporated from nectar, thus increasing the need for space to spread out the nectar. Temperature and humidity problems can be solved to a large extent by providing more space, removing entrance reducers, providing entrance mats and cracking lids or supers, setting them ahead slightly to allow more air flow. Apiary sites with poor air drainage should be avoided. Foundation and queen excluders should be used judiciously in order not to form a barrier to upward expansion. Honey-bound colonies should be bottom supered. Populous colonies may be used in areas with an early main nectar flow to keep the bees busy at work instead of planning to swarm.

Some colonies swarm no matter what. These colonies probably have a genetic propensity for swarming, and are good candidates for culling from a wintering operation. It also appears that packages are more inclined to swarm than are wintered colonies, possibly owing to a longer and less intensive brood-rearing period in wintered colonies as well as to selection away from swarming strains.

Swarm control — If in spite of the best efforts of the beekeeper a colony gets into the swarming condition there are several ways of preventing the bees from actually leaving the hive. From about mid-May onwards, regular checks include a check for queen cells indicating the initiation of swarming. Swarm cells are generally located along the bottoms and sides of the brood frames, and there are usually several cells at different stages of development. A quick method is to crack the brood chambers with the hive tool, pull the second a little forward and tilt it back, smoking the bees on the bottom of the frames so that they move up. Queen cups should be checked for eggs and young larvae. Queen cells containing older larvae and pupae are drawn out and are easy to distinguish (see figure 42). If swarm cells are found along the frame bottoms they should be crushed, and the colony should then be checked thoroughly for any cells elsewhere on the frames. At the same time extra space and means for ventilation must be provided, and brood nest congestion relieved. Swarm cells must be removed every nine or ten days to prevent the occurrence of swarming. If the colony is left longer than ten days with swarm cells the old queen may issue with a swarm, leaving the colony with several virgin queens on the point of emerging.

An effective, though time- and labor-intensive means of swarm control in colonies which have begun preparations is the Demaree method. This method involves confining the queen on one frame of brood in the bottom brood chamber along with eight empty combs. An excluder is placed on the first brood chamber and an empty honey super placed above the excluder. The rest of the brood is placed on top, with capped brood in the third position and open brood above that. The top boxes are checked about a week later to destroy any queen cells. The brood nest can be consolidated when the main nectar flow begins.

Often beekeepers clip one wing of their mated queens both to mark her and to help in swarm control. This operation will slow swarming but will not prevent it: the bees will leave the colony but will return when they discover that the queen is not with them. However, they will then wait until a virgin queen emerges and will swarm with her. At best the beekeeper is given a few days' grace before swarming occurs. Clipping wings is a delicate operation, requiring time and a gentle, steady hand. Virgins should never be clipped as they will then be unable to fly and mate.

Handling swarms — Generally swarms issue between 11 a.m. and 3 p.m., often on the first sunny day following a period of inclement weather, and will usually settle in a nearby tree or on a fence post for any time from an hour to a day or more. Once a new home is found the swarm then leaves its temporary location.

Swarms may be reunited with the parent colony or used to begin another colony. To hive a swarm a brood chamber with bottom board and cover is required. The box and bottom board are placed underneath the swarm and the branch given a sharp shake, whereupon most of the bees will be dislodged and fall into the box. If the queen remains on the branch the bees will soon rejoin her, but once she has been shaken into the box the bees will settle there. If the swarm is out of reach in a tree various methods to capture it include holding up a sack under the swarm on a V-shaped stick and rapping the branch to dislodge the bees, cutting off the branch and letting it down slowly to the ground, or cutting down the tree. The last method is not generally recommended, especially if the tree happens to be in the neighbor's back yard. The parent colony should be thoroughly checked for swarm cells and these should all be destroyed if reuniting, or all but one destroyed if not, to allow requeening while preventing afterswarms from issuing with newly-hatched virgin queens. Reuniting may be accomplished with the newspaper method, placing the swarm on top of the parent colony. If the swarm is to be kept separate it should be supplied with some food and left to settle in for several days. It should then be checked for disease and brood pattern and given extra space when required. Swarms are generally made up in part of many young bees which will quickly draw out foundation and produce honey.

VI. REMOVING HONEY FROM THE HIVE

WHEN TO REMOVE HONEY

The number of times that honey is removed depends on the beekeeper's preference and the size of the operation. A hobby beekeeper may wish to super the colonies and then leave them until the main nectar flow has finished before removing and extracting the honey. The commercial beekeeper who wishes to maximize honey production will remove honey supers from the colonies two and often three times through the nectar flow, replacing them with empty supers until the flow finishes. Colonies do tend to slow down a little as honey stores increase; if the honey stores are regularly removed then the colonies will continue to operate at a high pitch and overall yields will be higher.

The time of the first honey pull also depends, to some extent, on the beekeeper's preference and the number of colonies, as well as on such factors as the weather and the intensity of the flow. The beekeeper generally keeps a close watch on the colonies to know when supers are filling up at each site, and begins removing honey accordingly, commencing with the early yards and working around to the later yards. If a super has some weight to it and a good portion of the comb space is filled with honey, with cappings across the upper third of each frame, the super may be removed. Honey supers which are completely capped represent a loss in time and money. Under the dry prairie conditions capped honey may contain as little as 13-14 per cent moisture, while the maximum moisture content allowed in Canada No. 1 honey is 17.8 per cent. In addition, low moisture honey is thicker and more difficult to extract. Frames which are partially capped contain some low moisture honey and may also contain some higher moisture honey, averaging out to the correct percentage. Honey which drips like thin syrup or shakes out of a frame is unripe, and must be left on the hive for further processing.

Recently some prairie beekeepers have been experimenting with taking honey supers off after most of the excess moisture has been evaporated but before capping has begun. Bees more readily store ripened honey in cells which are not too full, and the last bit of cell length takes the longest to fill. Removing supers before cells are completely full may therefore increase honey yield, simply by providing more empty space and avoiding slowdowns related to lack of storage space. Also, if honey is removed before it is capped then honey which would otherwise be converted into cappings wax can be used to build out combs instead. Problems associated with handling wax in the honey house can then be avoided.

Finding the fine line between unripe honey and capped honey requires good judgment, precise timing, and topnotch management, as well as the use of a honey refractometer. Uncapped honey is often slightly higher in moisture content than is desirable, therefore the beekeeper must have some means of bringing moisture content down in the honey house before extracting (see section 8).

If the queen has moved into the honey supers, brood frames should be removed when the supers are taken off. Brood may be moved down into the second brood chamber, or accumulated in extra boxes and given to weak colonies as a third brood chamber. Usually after the first pull the nectar flow is on in full force, and the bees tend to form a honey barrier which keeps the queen from moving upwards again for the duration of the flow.

As honey supers are removed more empty supers are added. If nectar is still being brought in the second pull, hives may be supered again. Usually when honey supers are removed for the third time the colonies are left with just the two brood chambers. Occasionally a late flow will occur in which the bees produce another super of honey, but most late flows are minor and serve to fill up the brood chambers with stores for the winter or for next year's packages.

Removing honey from the hives should not be delayed, especially in a cool summer in regions where canola and mustard are grown. Honey from these crops tends to crystallize readily, even in the comb, and this honey is then impossible to extract.

ROBBING

Robbing can become a problem during honey removal especially in inclement weather and when the nectar flow has ceased. An effort should always be made not to expose honey supers in the bee yard. Supers should be covered with a tarp as they are loaded on the truck.

REMOVING BEES FROM THE HONEY SUPERS

There are several ways of removing bees from the supers before extracting.

Shaking and brushing — Supers to be extracted are taken off the hive and each frame is removed, the bees shaken in front of the hive with one or two sharp downward movements, and the frame replaced. A bee brush or any soft brush may be used to brush away stragglers. Alternatively, each frame may be brushed clean of bees. Shaking and brushing are quite effective in good weather when there is no danger of robbing. Bees tend to get quite cross when they are brushed; shaking in front of the hive seems not to anger them as much. A smoker should be on hand to help in handling them.

Bee escape boards — Bee escapes work as one-way gates; bees can go through but cannot return (figure 27). If an inner cover containing one or more bee escapes is placed between honey supers to be removed and the rest of the hive, the bees tend to move down to the colony, thereby vacating the honey supers. Bee escapes work quite well providing that there is no brood in the honey supers, for bees will not leave brood. Equipment must be bee-tight, otherwise the supers may be robbed of all the honey before the beekeeper comes back to remove them. Honey supers are best removed in the early morning before bees are flying. Bee escape boards may be enhanced by placing them directly above a shallow super containing no frames, thereby giving ample cluster space for the vacating bees. A two-inch diameter screened hole in the centre of the bee escape shown (figure 27) further enhances effectiveness.

Bee escape boards are useful especially in smaller

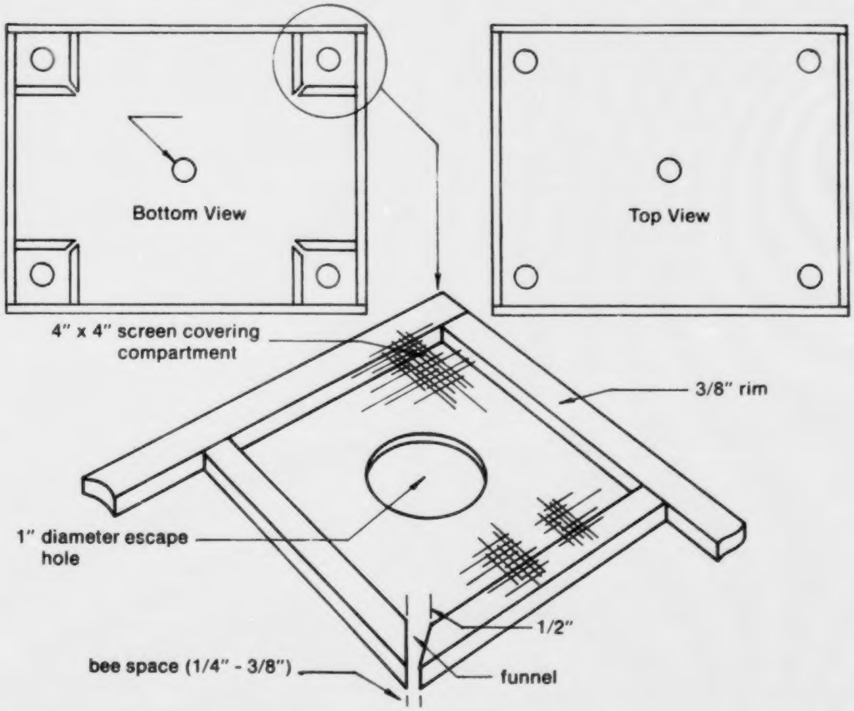


FIGURE 27.
Bee escape board.

operations and for hobby beekeepers. Their use necessitates two trips to the bee yard from one to three days apart, and the honey supers must be lifted twice. Empty supers must be available for each hive before full supers are removed and extracted, so extra hive equipment may be required.

Fume or acid boards — Fume boards (figure 28) are the most common means of taking honey off hives. They are made up of a wooden frame with two layers of absorbent fabric such as flannelette tacked over one side, covered with tin which is painted black for heat absorption. One of three different chemicals is sprinkled on the fabric. Outer covers are removed, the bees are smoked to start them down and the fume boards placed on top of each hive. The fumes act as a repellent, driving the bees down. The top super is removed when all the bees have moved out, a few more puffs of smoke are given, and the fume board is placed atop the next super, until all honey supers have been cleared of bees and removed.

The major drawback to the use of fume boards is the possibility of honey contamination. Care must be taken to make the rim of the fume board deep enough (5 cm) that the chemical does not directly contact any wax or honey on top of the frames. All burr comb must be removed before placing the fume board on each super. Also, it is not necessary to soak the flannelette; a few drops of the repellent chemicals will do the job, and will not then drip in the honey super.

The beekeeper should not use more fume boards than he or she can keep up with, and this number will depend on the number of people on the crew and the weather conditions. If fume boards are left on the hives too long the possibility of honey contamination is greatly increased.

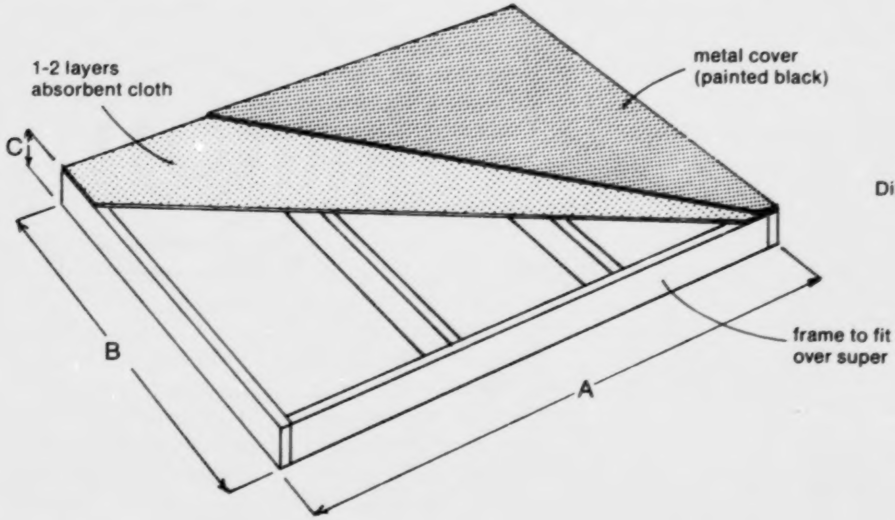
Stacking the fume boards immediately after finishing in each yard will help to retain the effectiveness of the chemical for the next yard.

Carbolic acid (phenol) — Carbolic acid is very fast acting on sunny days but is ineffective under cloudy conditions. The sun causes the acid to vaporize and the heavy fumes sink through the hive. If left on too long, carbolic acid fumes will drive the bees right out of the hive.

Carbolic acid is extremely dangerous. It can cause severe burns and blindness if handled incorrectly. It is neutralized by alcohol. If skin or eyes are contacted they should be flushed continuously with clean water. Rubber gloves and coveralls should be used when handling carbolic acid and fume boards.

Butyric anhydride (Bee-go) — Butyric anhydride is also effective as a bee repellent, and works at lower temperatures than does carbolic acid.

Benzaldehyde — Benzaldehyde is effective as a bee repellent if used correctly. If too much is sprinkled on the fume boards, or if the boards are left on too long especially in sunny weather, benzaldehyde tends to confuse and stupefy the bees so that they do not move down. When using benzaldehyde, smoke must be used to start the bees moving, and a little additional smoke given every minute or two. On hot sunny days the



Dimensions A = 508 mm = 20 in.
B = 420 mm = 16-1/2" in.
C = 50 mm = 2 in.

FIGURE 28.
Acid or fume board (cut away view).

boards may be placed cross ways to allow ventilation, or protected from the sun with insulation or an outer cover.

Benzaldehyde oxidizes to form white crystals of benzoic acid. Fume boards should be hosed off every few days, as benzoic acid is combustible and a fire hazard in stored equipment. If handled carelessly benzaldehyde can cause skin irritation.

BEE BLOWERS

Bee blowers utilize forced air to remove bees from the honey supers. Many commercial beekeepers use them as a back-up system for cold cloudy days. They are especially useful when queen excluders are on the hives, as excluders inhibit the downward movement caused by fume boards. Blowers can also come in handy in the fall to reduce colonies to two brood chambers for wintering or to blow dead bees out of equipment after killing colonies.

Blowers are available in backpack and free standing models, with stands and chutes of various descriptions to direct bees to their hive entrances. They are a fast and efficient, though noisy, means of removing bees from supers, and bees do not seem to become angry or aggressive. There is a possibility of queen loss if she is blown from the honey supers and does not find her way back to the hive.

LOADING AND MOVEMENT OF HONEY SUPERS

While the "armstrong" method of moving heavy honey supers within the bee yard and honey house may be sufficient for a small number of hives, heavy lifting is one of the chief drawbacks of beekeeping. There are various devices that can be used by beekeepers to alleviate this problem.

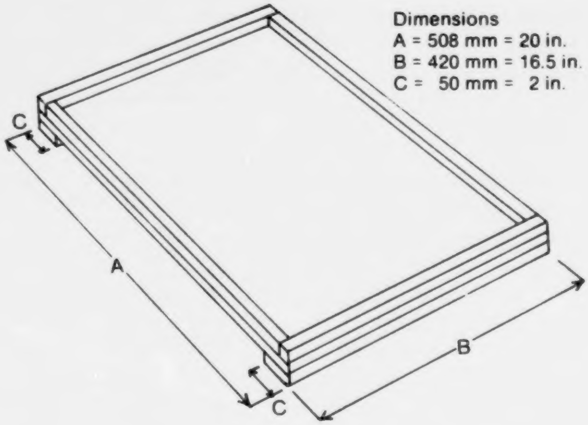


FIGURE 29.
Honey super pallet.

Good quality single-stack pallets greatly simplify the movement of honey supers, and act as trays to catch any dripping honey (figure 29). Supers are placed on pallets on the truck and further movement on the truck and in the honey house is accomplished with a super cart. Tailgate loaders are available on which supers may be stacked on pallets, then lifted mechanically and wheeled into place on the flatbed with the cart. Alternatively, boom hive loaders may be used to facilitate movement of honey supers as well as honey bee colonies.

Some commercial beekeepers with many colonies have converted to a palletized system. Colonies are arranged in groups of two or four on pallets and are then handled as a unit by means of a forklift. Moving honey supers to and from the bee yards then becomes simply a matter of moving pallets of supers with the forklift.

VII. HONEY

Honey is a sweet, viscous liquid which is produced from nectar by bees. Once stored and capped in beeswax combs, honey remains stable and can be used as food by the bees over many months. If handled properly by the beekeeper honey retains its keeping quality, but it must be remembered that honey is a potentially perishable food product. If care and attention are not given to its handling from comb to container, honey can easily lose its unique and delightful fragrance and flavor and can even spoil.

COMPOSITION

Honey is composed primarily of the invert sugars levulose and dextrose (alternate forms of fructose and glucose), with small amounts of sucrose, maltose and other sugars, minerals, proteins (mainly enzymes), pigments, acids and essential oils which add fragrance and flavor. The Canadian Food and Drug Act defines honey as containing not more than 20 per cent water, 5 per cent sucrose and 0.25 per cent ash (minerals), and not less than 60 per cent invert sugars. Fragrance, flavor and color vary according to the plant species and range from white and mild-flavored to dark and strong-flavored.

VISCOSITY

Honey is viscous, that is, it has resistance to flow, and this resistance affects the movement of honey through the extracting system. Viscosity also affects the rate at which air bubbles and suspended particles such as wax float to the surface. Thick honey has a high viscosity or good body; thin honey has low viscosity. Both the temperature and moisture content of the honey affect its rate of flow, with warm temperature and high moisture content giving a decreased viscosity. Thus, viscosity is the reason behind keeping honey supers in the hot room for a day before extracting, and heating the sump and the settling tanks. There is a rapid viscosity decrease up to 30.3°C (86.5°F) for honey with a 17.5 per cent moisture content, and very little is gained by keeping honey temperatures higher than that. For lower moisture honeys a temperature increase of 3.6°C for each percentage decrease is needed to obtain the same viscosity so a low moisture honey may require a dangerously high temperature for extraction.

MOISTURE CONTENT AND HYGROSCOPICITY

The moisture content of honey affects its viscosity, weight, handling, grading (see the appendix), rate of granulation, and tendency towards fermentation. Moisture content can be easily determined with a honey refractometer, available at bee supply houses. The specific gravity of honey, or its weight in relation to that of water, is higher than water and varies with the moisture content: the higher the moisture content the lower the specific gravity. Consequently, a given volume of 14 per cent moisture honey weighs more than the same volume of 18 per cent moisture honey.

Honey is hygroscopic, that is, it will absorb water from the atmosphere until an equilibrium point is reached. For 17.4 per cent moisture honey, this equilibrium is reached at 58 per cent relative humidity (R.H.), and moisture will neither be gained nor lost at this R.H. Other honeys held at 58 per cent R.H. will gain or lose until they reach 17.4 per cent moisture. A low R.H. will cause moisture loss from the honey to occur, thus when honey supers are stored in the hot room there is a chance of moisture loss unless the relative humidity is maintained at 58 per cent. This principle is used in reducing the moisture content of high-moisture honey before extracting, by blowing warm, dry air over the surface of the honey combs. A wet and dry bulb thermometer may be installed in the hot room for keeping track of relative humidity, while a refractometer may be used to monitor the honey. Honey stored above 60 per cent R.H. will absorb water from the atmosphere, initially into the surface layers and gradually throughout, which may bring its moisture content to unsafe storage levels and cause spoilage through fermentation. Fermentation will also occur if high-moisture honey is extracted and stored rather than treated to bring the moisture content down before extracting. Once honey is extracted its moisture content is very difficult to lower except by thorough blending with a low moisture honey, a process which is beyond the scope of most commercial beekeepers.

GRANULATION

Honey is a supersaturated solution of dextrose in the presence of levulose, and in time the excess dextrose generally precipitates and forms crystals. Granulated honey, then, consists of crystals of dextrose surrounded by a solution of levulose and water. The tendency of a honey to granulate depends on its relative proportions of dextrose and levulose. Honeys with a high dextrose content, such as canola and dandelion honeys, will granulate very quickly while honeys with more levulose such as fireweed honey may granulate very slowly or not at all.

Honey must be seeded with dextrose crystals for granulation to occur, whatever the sugar ratio. Dextrose crystals may be present in wet honey supers, in the extracting system, and even floating in the air in the honey house. Once the crystals enter the honey, granulation will begin around each crystal. Temperatures fluctuating between 5°C and 7°C appear optimum for the initiation of granulation, while temperatures around 14°C (10°C - 18°C) are ideal for granulation to proceed rapidly. Above 27°C and below freezing granulation does not occur; below 10°C granulation occurs very slowly. High moisture honey will result in a creamier, softer granulation and low moisture honey crystallizes more coarsely. Placing honey storage tanks in a heated location or using water-jacketed tanks for settling will keep granulation from setting in before the honey is packed.

REDUCING HONEY QUALITY

To be of high quality, extracted honey should be as similar to honey in the comb as possible. Improper handling may incorporate wax particles and air bubbles into the honey which will give it a cloudy appearance. Dust, dead bees and other foreign objects in the finished product are evidence of lack of adequate care and sanitation. Honey is most easily damaged through high moisture content and high temperatures when handling and storing.

Fermentation — Few organisms can tolerate honey's high sugar content but there are several sugar-tolerant yeasts which occur naturally in honey. At moisture levels below 17.1 per cent these yeast species survive in a dormant form but cannot reproduce themselves. However, when the moisture content is over about 18 per cent the yeast cells can begin to grow and multiply, feeding on the sugars and changing them to alcohol and carbon dioxide (CO_2), resulting in honey spoilage or fermentation. The alcohol may break down to acetic acid (vinegar) and water, giving the honey a distinctly sour and "off" taste and a runny texture with small bubbles, surface heaving or foaming due to the presence of CO_2. Extensive fermentation will cause containers to burst their lids and overflow.

Honey from 17.1 per cent to 18 per cent moisture will be relatively safe from fermentation, requiring 1000 yeast spores per gram of honey for fermentation to occur. With between 18.1 and 19 per cent moisture, fermentation within a year is more likely, as only 10 yeast spores per gram of honey are required. If the moisture content is over 19 per cent, fermentation will undoubtedly occur.

Besides moisture content and yeast count, the extent of granulation and the storage temperature will affect honey's tendency to ferment. Once dextrose has crystallized the resulting solution of levulose and water may be higher than is safe for honey storage, and fermentation may occur in this liquid portion. Storage temperatures under 10°C are desirable in that granulation occurs slowly, and yeasts do not grow or reproduce at all. For small amounts of honey freezing is ideal, as neither granulation nor fermentation will occur while in storage. Fermentation will not occur at temperatures above 27°C, but long-term storage at such high temperatures will damage the honey.

The process of pasteurization serves both to kill the vegetative form of the yeasts and to dissolve dextrose crystals and retard granulation. Table 5 gives the minimum time periods and temperatures at which honey must be held for yeasts to be killed. At high temperatures the time periods are extremely short, and a system of flash heating and immediate recooling must be used to avoid heat damage to the honey (see below). Honey which has begun to ferment can be heated to 66°C for a short time: this heat treatment will stop further fermentation and may drive off the sour taste.

TABLE 5. Yeast Destroying Temperatures and Minimum Time

Temperature	Time
52°C	470 min
54°C	170 min
57°C	60 min
60°C	22 min
63°C	7.5 min
66°C	2.8 min
68°C	1.0 min

Taken from Townsend, G.F. Preparation of honey for market. Ontario Ministry of Agriculture and Food. Agdex 616. 29 pp.

Heating and storage — Heat is used in the honey house and packing plant to reduce viscosity, kill yeasts, dissolve crystals, and make processing simpler. If excessive heat is applied to honey during handling, the honey quality will suffer, through changes in fragrance, flavor, and color. These same changes will occur if honey is stored at temperatures above 10°C. The higher the storage temperature the shorter the time period before quality begins to deteriorate.

Tests have been developed to measure the level of a chemical breakdown product, hydroxymethylfurfural (HMF), in honey samples as an index of deterioration through overheating or poor storage conditions. Levels of honey enzymes such as diastase and invertase can also be monitored, as enzymes are generally sensitive to heat. These factors are important especially to the beekeeper who wishes to sell honey overseas, as some countries will require certain HMF and diastase levels as indicators of proper processing. Honey to be graded and classed under the federal regulations must meet certain HMF and diatase levels, as outlined in the appendix.

Food thermometers can be used to check the temperature of honey as it runs through the extracting system, paying particular attention to temperatures in sump, tanks and heat exchangers.

VIII. EXTRACTING THE HONEY

Whether designing a new facility or altering an old one, the beekeeper should first visit with other beekeepers and discuss the advantages and disadvantages of their honey houses, extracting systems and storage facilities. The beekeeper should also remember that while the honey house must be adequate, it need not be luxurious. If money is not available to manage the beekeeping operation then the honey house will be of little value.

Honey House Types — Most modern honey houses are of the single-storey type, with relatively simple construction, single-level concrete floors, high ceilings and large doors. Two-storey honey houses allow the use of gravity flow for some of the extracting process. However, unless this type of honey house is built into a hill to allow off-loading on both floors, moving equipment from one floor to another will be awkward and time-consuming. The availability of good quality honey pumps overcomes the disadvantages of single-level honey houses. In addition, one-storey buildings are more easily expanded, altered, and adapted to other types of industry.

An old building such as a school can often be altered to make a very good honey house. Floors and foundations may need to be strengthened to take the weight of honey supers and barrels. For the smaller beekeeper a garage or small shed will be quite adequate.

Space — Whether the honey house is a specially-constructed building, a converted schoolhouse or a two-car garage, there are several considerations to make in planning its layout.

A major consideration in the honey house is that there be ample space for moving honey and equipment easily and efficiently. It is very important to have an efficient flow-through from unloading to reloading the honey supers and from uncapping to packing the honey (figures 30 and 31). The layout should be carefully planned to avoid bottlenecks. One method of deciding on a floor plan in the extracting room is to make a scale cutout of the room and each piece of equipment, and rearrange the cutouts to find the best equipment arrangement.

The use of sliding or overhead doors further conserves available space when compared to swinging doors. Sliding doors are recommended in area of heavy traffic such as entrances to storage areas, the hot room and the extracting room.

Space is also required for temporary storage of honey supers before and after extracting, storage for honey containers and winter storage of hive equipment.

Ambitions for expansion must be taken into account. Should the beekeeper plan to palletize the beekeeping operation then the honey house must allow for the future use of forklifts. As farm sales increase a salesroom may become desirable. Workshop space will be required, and a staffroom and wax-rendering area may be considered. Wax-rendering and boiler rooms should be located in another building, if possible, to alleviate the danger of fire in the honey house.

Cleanliness — Of equal importance to space is cleanliness. It is in the beekeeper's best interests to maintain high standards of cleanliness to ensure the high quality of his or her food product. The honey house and its surroundings must meet certain sanitation criteria in order to obtain a producer-grader certificate. Close proximity of livestock and stagnant water is not recommended. A gravelled or paved yard will do much towards keeping vehicles, loading docks and floors clean and free of mud and dust. The honey house and storage areas must be bee-tight; windows should be screened and provided with bee escapes, and doors spring-loaded so that they cannot be inadvertently left open. Plenty of light, both natural and artificial, in the extracting area will help to make it a safe and pleasant place to work. Windows may also provide ventilation, and fans may be installed for ventilation and to reduce humidity. Walls should be clean, washable and painted a light color; floors should ideally be of concrete, smooth, painted or treated for protection against the acid action of honey and water, and kept clean, with adequate drain facilities. Wooden floors should be tiled or coated with varnish. Some beekeepers use stainless steel skirting on the lower metre of the walls for ease of cleaning and protection against forklift damage. Washroom facilities must be available for personnel.

Honey, when diluted with water and dead bees, will ferment and give off an objectionable odor. This can be avoided by having drainage water carried well away from the establishment rather than allowing it to stand in close proximity to the extracting facility. Honey and wax spills should be cleaned up immediately with a minimum of water. Too much water will simply spread the honey in a thin film, resulting in sticky floors and a fermentation problem. Joints between floor and walls should be sealed with a silicone sealant or coving to prevent water and honey from seeping under walls and fermenting there.

Regular cleaning sessions during daily operation prevent a buildup of the stickiness often associated with honey houses. Each worker should be provided with a bucket of clear water and wash rag and be made responsible for the cleanliness of his or her area. At designated times of the day, extracting should cease and a few minutes be devoted to cleaning only. This may be 15 minutes prior to lunch and quitting time. In this way honey and wax has no chance to accumulate and become a formidable cleaning task at the end of the season. Special attention should be paid to bee specks on walls and around lights which will require washings to avoid buildup. A shop vac is especially useful in removing bees from windows and lights should they gain entry. It is imperative that the vacuum cleaner be emptied each day some distance from the honey house; otherwise the dead bees begin to smell.

Location — Another consideration when a new honey house is being planned is its location. In location and construction the resale value of the facility must be considered. If built away from the beekeeper's residence it can in future be sold and the residence retained. Also, exposure of the beekeeper's family to occasional stings can then be avoided, which is especially important if family members have had allergic reactions to bee stings. Location of the honey house on the outskirts of a town is convenient in terms of availability of services and adequacy of roads. However, caution is advised in locating too close to residential areas as future zoning by-laws may cause problems.

Insurance — Insurance is, of course, a necessity for sideline or commercial beekeeping operations. Premiums will depend on the location and design of the honey house and storage facilities; if located in or near a town with a fire department premiums will be

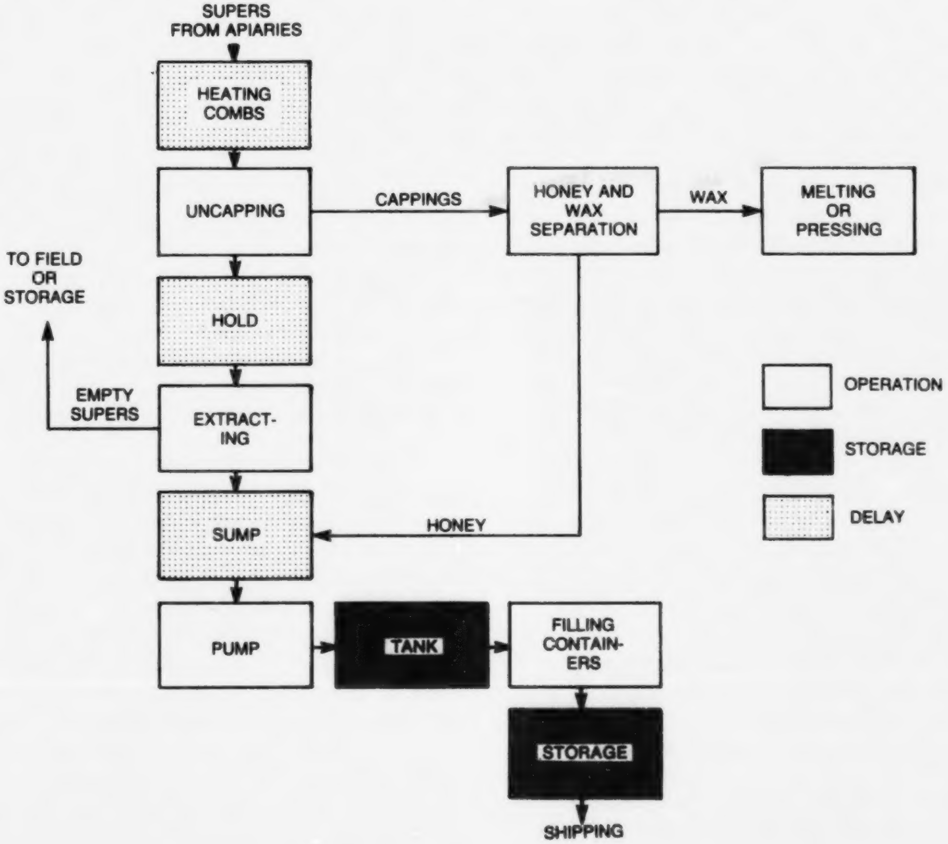

SUPERS FROM APIARIES
HEATING COMBS
UNCAPPING
CAPPINGS
HONEY AND WAX SEPARATION
WAX
MELTING OR PRESSING
TO FIELD OR STORAGE
HOLD
EMPTY SUPERS
EXTRACTING
SUMP
HONEY
PUMP
TANK
FILLING CONTAINERS
STORAGE
SHIPPING
OPERATION
STORAGE
DELAY

FIGURE 30.
Flow diagram showing operations necessary in extracting honey for bulk shipping.

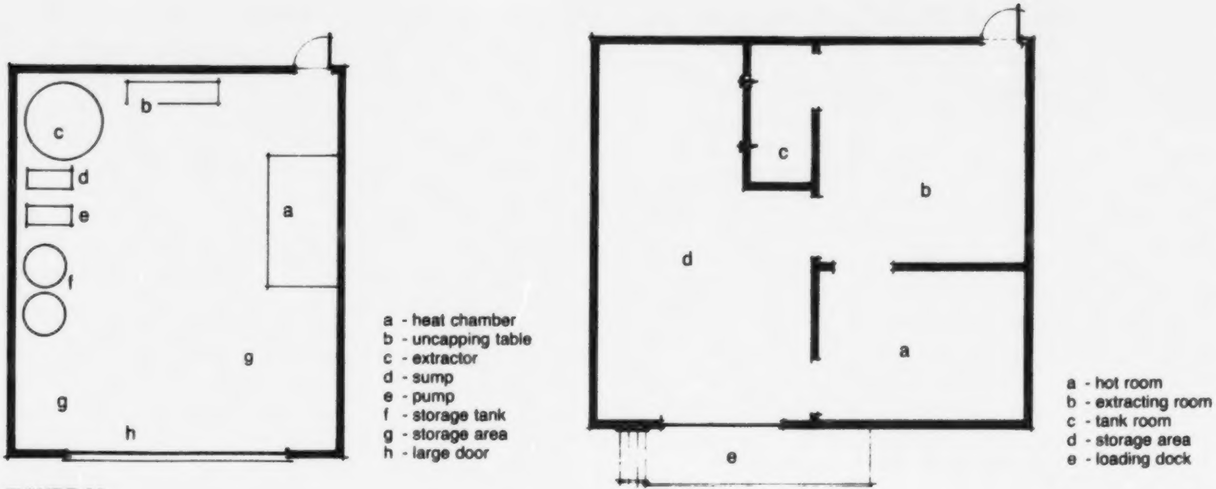


FIGURE 31.
Honey house layouts.

reduced. Also, locating wax-rendering facilities and storage areas in separate buildings will reduce premiums.

COMPONENTS OF THE HONEY HOUSE

The loading area — The area for unloading and loading trucks should be enclosed for protection against poor weather and robbing bees. If forklifts are not used a raised dock is necessary for level off-loading. There must be adequate space for manoeuverability with both forklifts and super carts. The loading area, if large enough, may also serve as temporary storage space for equipment or barrels. Both hot room and storage area should have direct access to the loading area.

The hot room — The hot room is the place where honey is warmed to reduce viscosity and, if necessary, dried to reduce moisture content. It should be large enough to accommodate three days' extracting supply, in case of poor weather or extractor breakdown. An area of about 0.26 m^2 (3 sq ft) should be allowed per single stack of supers. The room is kept at temperatures between 26°C and 32°C (80°F - 90°F). Fans may be used to circulate the warm air. There should be two doorways so that honey supers can be moved from truck to hot room and from hot room to extracting room without having to restack or move supers within the hot room.

If honey is high in moisture content it must be dried before extracting. An efficient system of air circulation within the supers is needed for drying honey. Dry air is circulated up through the supers, which are staggered or stacked on side-slatted pallets; the moist air is then exhausted at ceiling level. Dehumidifiers may be incorporated into the system, if desired. A large air volume in the room and a high rate of air exchange will speed up the drying process. An efficient system will allow about a 1 per cent moisture loss in 24 hours. As mentioned in chapter 8, at a relative humidity of 58 per cent honey at 17.4 per cent moisture will neither gain nor lose moisture content. Naturally, then, the lower the relative humidity that can be maintained in the hot room the better will be the honey drying process.

Alternately, should the honey be too low in moisture content for easy extraction, the relative humidity in the hot room can be increased by sprinkling water on the floor. A humidity gauge in the hot room will aid the beekeeper in maintaining relative humidity.

A single window will attract stray bees, which may be released through a bee escape or removed by vacuuming. One type of bee escape is a wire mesh cone directed outwards and upwards, with the tip of the cone large enough to allow the passage of one bee (about 5 mm). Some beekeepers place a black cardboard triangle in the window and bee escapes in each upper corner, so the bees are attracted to the areas of light and eventually find their way through the bee escape. A small catcher colony with one or two frames of brood may be placed outside the window to attract the stray bees. At intervals this colony may be taken to a bee yard and the bees used as a nucleus or added to another colony.

The extracting room — The extracting room contains the extracting system (see below) and equipment for handling wax cappings. As this is the centre of the honey house operation, it should be a pleasant place in which to work, both day and night if necessary. Walls should be painted a light color, there should be adequate lighting and there should be enough windows to allow natural light.

Adequate space around machinery must be maintained for easy movement and for cleaning purposes. One should design the floor plan so as to avoid the excessive movement of stacks of supers around the extracting area. If the entrance to the hot room and the exit to storage are in the same general area, (or if the plan utilizes a central manoeuvering area), the frames, after removal from the boxes, move through the extracting system and return to the close proximity of the empty boxes. The extracted frames are then reloaded into the boxes and either returned to the field or to the storage area. Larger operations may utilize conveyors or portable frame accumulators to accomplish this U flow concept and thus avoid the excessive use of forklift or hand carts in the extracting area.

The tank room and filling room — Locating tanks in the hot room or another heated area will facilitate settling and retard granulation. The filling area should not be in the hot room but may be on the other side of the wall, and should have easy access to temporary storage and loading areas. A scale is located in the filling area for weighing barrels.

The storage area — Storage space is needed for honey containers, both empty and full, and for hive equipment.

Empty barrels are often stored outside, but ideally should be stored at least under cover to protect them from dust and rain. Ideally, full barrels are stored under cover, convenient to the loading area, until shipped out.

If stored outside, full barrels must be protected from precipitation by means of a roof or tarpaulins. Water must not sit on the barrel lids, especially if bungs are present in the lids, as seepage into the barrel will occur. Plastic barrel liners help to protect barrelled honey from picking up moisture.

Hive equipment is stored over winter in unheated warehouses. Beekeepers should seriously consider storing hive equipment in separate buildings from the honey house as a precaution against total loss from fire. Losing honey supers just before the nectar flow would be disastrous whatever the insurance payments.

HONEY EXTRACTION

Choice of the extracting equipment to be used will depend on the size of the beekeeping operation, the available space, equipment costs, the extracting rate desired, availability of personnel, and the personal preference of the beekeeper. Whatever the choice, the components of the system should be matched so that, for instance, the wax separating device is compatible with the method of uncapping, and the uncapper and extractor have similar capacities.

Safety Considerations — As in all factories and food-processing plants, certain safety precautions must be taken in the honey house. At the very least, drive belts, pulleys, and conveyor chains should be covered, both to prevent their being gummed up with honey and wax and to prevent accidents. Loose clothing should be avoided and rings should be removed when operating extracting equipment. Long hair should be arranged so that there is no danger of getting it caught in conveyors or belts.

Honey and water are efficient conductors of electricity and electrical shocks can occur if wiring has not been done properly. Electrical switches should be enclosed in waterproof boots and electrical conduit should be waterproof, with waterproof fittings where it enters motors and switches. Conductors should enter switches and motors from the bottom so that there is no possibility of water leaking into equipment when it is washed down. Electrical motors should be of the enclosed type to prevent danger of shock when washed. Safety codes should be followed in all wiring procedures.

The forklifts used in palletized beekeeping operations may cause accidents if overloaded or driven without care, and should not be used in the extracting room. The operator and other personnel must always be aware of each other's position. Fumes from gasoline-driven forklifts may constitute a health hazard in enclosed areas.

Pallets — Honey supers should always remain on pallets which are constructed to catch dripping honey (figure 29). Pallets allow simplified movement with forklift or super cart and alleviate the necessity of continual cleanup of sticky floors.

Uncapping Devices — When the honey in the combs is warm and at the desired moisture level the combs are ready to be extracted. There are many different devices on the market for removing the wax cappings from the combs. These devices range from fork-like comb scratchers, to hand-held knives and planes which are heated by electricity or steam, to stationary jiggle knives across which each frame is moved by hand, to electric or steam-heated machines which carry each frame on conveyor chains through vibrating knives, chains or perforating rollers, by which wax cappings may be sliced off or chipped away. The depth of the cut is adjusted to accommodate different comb widths and the beekeeper's preference for a deep or shallow cut. The wax cappings with honey are gathered below the uncapper for further processing.

Super elevators are available to lift each honey super to a convenient height, thus facilitating handling of the honey frames and avoiding constant bending. A stack of supers is wheeled from the hot room and placed directly on the super elevator, which is located to the side of the uncapping device. Some beekeepers build a platform fo the correct height by the uncapper on which supers are manually placed; however, this method requires more handling of heavy honey supers.

At some point during the uncapping process burr comb may be scraped off each frame. Some beekeepers station a person to do the scraping while checking uncapped frames and scratching any intact cappings. Others scrape top bars while still in the supers or on a stationary blade before uncapping. Regardless of the method, the burr comb then joins the wax cappings.

In large operations, a holding tray of some sort will be necessary for uncapped frames before they are loaded into the extractor. This tray, generally of stainless steel or galvanized metal, may be connected to the uncapper, and uncapped frames move to the tray either by means of continuous conveyor chains or by pressure from following frames. The holding tray also acts as a drip tray, and honey and wax particles are then drained into the cappings system or into the sump.

Extractors — All honey extractors use centrifugal force to remove honey from combs. Tangential extractors (figure 32) are available for from two to sixteen frames but are more common in the two or four frame size. Frames are placed in expanded metal baskets and honey is extracted from one side of the frames at a time. Frames must be reversed when the first side is half extracted to avoid frame breakage. The second side is then fully extracted after which the frames are once more reversed to complete the extraction of the first side. Reversing is accomplished either by removing the frames or by reversing the baskets, depending on the extractor. These extractors are either hand or power driven. The actual extraction time is very short, and these extractors are ideal for the hobby beekeeper with from one to ten colonies.

Radial extractors are available to hold from ten to one hundred or more full depth honey frames (figure 33). Some beekeepers alter extractors or have them custom-built to extract combs in the supers. Ten-frame radial extractors are available in hand-driven models but are generally power driven; both mechanical and electrical controls are available. Frames are loaded like spokes of a wheel, with bottom bars towards the centre and top bars outwards, and honey is extracted simultaneously from both sides of each frame, taking advantage of the slight upward slant of the wax cells. Extraction time varies, depending on the weight of the frame and the honey viscosity. The number of revolutions per minute increases slowly at first, to prevent damage to the heavy frames, and then more quickly as the frames become lighter.

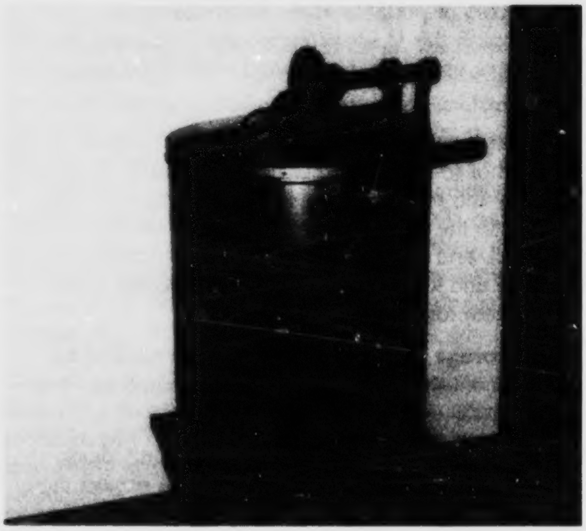
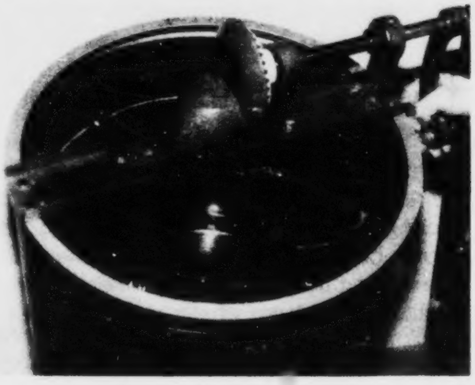


Figure 32:
Two-frame tangential hand driven honey extractor.
A: extractor. B: internal view showing reversible baskets.



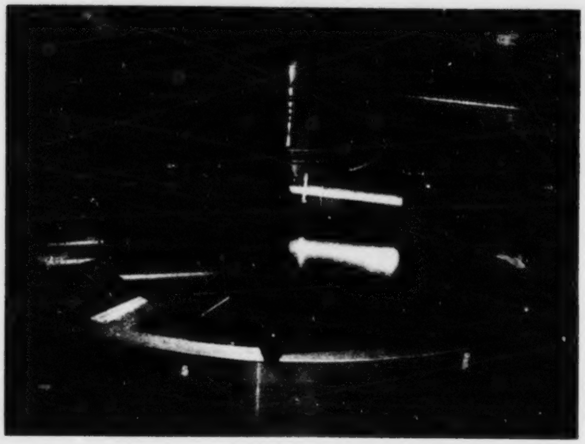


Figure 33:
Vertical axis radial extractor loaded with frames.

Extractors are also available in which frames are loaded horizontally rather than vertically, as pictured in figure 34. Larger extractors of this type can be loaded by pushing the correct number of frames from the drip tray onto each rack, which also acts to push the extracted frames out to a holding rack where they can be easily loaded into supers. Automatic loaders are also available. These extractors do not cause as much frame breakage as do conventional extractors because the direction of both acceleration and centrifugal forces are parallel to the comb surface rather than perpendicular. Extraction time is less, as without the risk of comb breakage acceleration time can be decreased.

Many extractors are now made of stainless steel to protect the quality of the honey and for ease of cleaning. Iron and steel will darken honey; galvanized extractors should be regularly checked to make sure that there are no chips or scratches.

There have been recent technological advances in honey extraction systems. One manufacturer has developed an integrated system which features automatic removal of frames from the boxes, automatic scraping of top and bottom bars, an automatic uncapper and a 120 frame automatically loading-unloading horizontal axis extractor. As extracting equipment is continually improving, one should contact beekeepers, apiculture specialists and manufacturers regarding the most recent technology before purchasing a new extracting system.

The sump — Extracted honey drains by gravity into a sump or holding tank, located below the level of the extractor. Often honey from the cappings also drains into the sump. The sump is usually water-jacketed to keep the honey warm, which allows initial separation of wax, air bubbles and foreign particles. The sump may be covered to keep dust out of the honey. Baffles or coarse screens may be used to further aid in settling, as well as to keep foreign objects from running through the pump. Honey is then processed further at a uniform rate, with the pump intake at the base of the sump to avoid incorporating air into the honey. The pump is activated by a float when the honey reaches a certain level in the sump and turns off before the level reaches the pump intake.

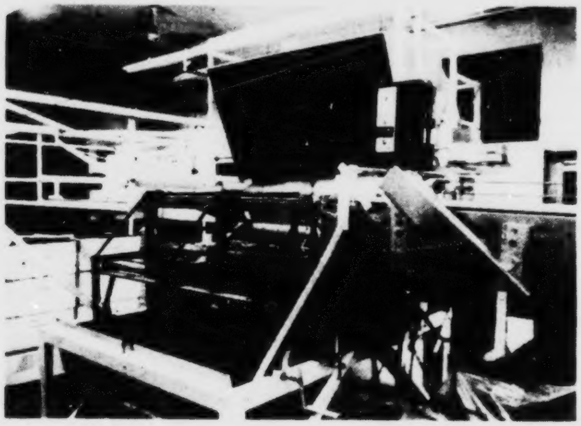


Figure 34:
Horizontal axis radial extractor.

The honey pump — Pumps are used if gravity flow is not available to run extracted honey to strainers or settling tanks. It is very easy to incorporate air into the honey in the pump if it is not correctly adjusted. Because honey has high viscosity the pump should be larger than those used to pump thin liquids. It should be operated only fast enough to keep up a continuous flow, generally at less than 40 per cent of its maximum. Allowing the honey to flow into the pump rather than the pump having to lift the honey will keep the pump primed. The larger the intake and outlet pipes the less pressure will be needed to move the honey and therefore the less power required. The intake pipe should be larger than the outlet pipe: a 5 cm intake and a 3.8 cm outlet will usually be sufficient. Right angles and long lifts in the pipe require more power to keep the honey moving. A specialized honey pump will be needed to move both honey and wax cappings, as is the case when using a honey-wax spin-float separator.

Settling tanks — Tanks vary from honey drums with gates, to modified milk tanks, to custom-made stainless steel or galvanized tanks with baffles. Since commercial beekeepers who sell honey in bulk utilize settling as their primary means of removing foreign particles and air bubbles from honey, tank capacity should be available to allow two or three days' settling before running honey into barrels. Several adjoining tanks may be used, each with a day's extracting capacity, or a single adequately baffled tank may be preferred, with inlet at one end and outlet at the other. Having several separate tanks is useful where specialty honeys such as buckwheat honey are produced, in order to keep different colors and qualities separate. The beekeeper may also wish to keep his or her best quality honey separate for retail sales.

Tanks should be water-jacketed or located in a heated room to keep honey at about 32°C, which reduces viscosity, aids in settling and retards granulation. Covers will prevent contamination of the honey by airborne dust and dextrose crystals. Stainless steel is the material of choice; galvanized tanks and tanks painted with special paint for food containers are also adequate. Float alarms should be installed to warn against overfill. Frequent cleaning of tanks should not be necessary; a layer of wax particles on top of the honey helps in filtration of added honey. This wax layer may occasionally be skimmed from the tank, allowed to drain in wire baskets and run through the wax handling system. In the meantime, tanks should not be drained so low as to reincorporate the wax layer into the honey.

Straining honey — If the beekeeper plans to sell honey directly to consumers and on the retail market, a means of straining the honey will be necessary. Generally strainers are located between sump and settling tanks or in the tanks. A baffled and water-jacketed sump removes the coarsest particles and warms the honey, both necessary prerequisites to movement of honey through a straining mesh. Canada No. 1 honey requires straining through mesh with 0.018 cm openings (see Appendix). Nylon (45 mesh/cm) and Swiss silk bolting cloth (26 mesh/cm), and Monel metal screen are all satisfactory, provided that the honey is around 40°C and contains no granulation. Higher honey temperatures will soften wax particles so that they clog up the strainer or pass through, resulting in a cloudy honey.

Bags of straining cloth are submerged in tanks and supported by stainless steel cages, so that straining occurs below the honey surface and over a large surface area. Straining bags should be exchanged when they begin to get plugged up.

Packing honey — Once settled and strained, honey is then packed into bulk or retail containers. Each tank is fitted with a honey gate for filling containers. If tanks are joined together a single honey gate can be used. A scale is located under the gate or nearby for noting barrel weight before and after filling. Barrels should be clean and completely coated with paint recommended for food containers. If not, plastic barrel liners are available to keep the honey from contacting poor quality barrels.

Honey gates on large tanks can be equipped with shut-off valves in case the gate is knocked off or somehow damaged. Shut-off valves comes highly recommended by those beekeepers who have learned about them the hard way.

Retail containers must be new and clean before filling. An accurate scale will be necessary to ensure a correct net weight. Containers should be attractively labelled with the word "honey" the beekeeper's name and address, the net weight of the honey, and the honey grade where required by provincial or federal regulations (see the appendix).

HANDLING BEESWAX CAPPINGS

Honey makes up a large percentage of the weight of wax cappings, and this mixture must be handled carefully to separate honey and wax while damaging neither. There are several methods used for separation which do not require extra heat:

Draining — Small beekeepers can uncap directly into a drain tub of some sort, for example a screened super with a slanted galvanized metal tray attached to the bottom with a drain at one end, or a screened washtub. Cappings are allowed to drain for 24 hours or more in a warm room. The honey is then drained into the sump or strainer and processed as usual. Cappings can then be stored temporarily or melted down immediately (see below, Rendering Beeswax Cappings).

Feeding cappings back to bees — Taking the cappings back to the bee yard and allowing the bees to clean them up is not generally recommended because of the danger of inciting robbing and the potential for spread of American foulbrood disease. Cappings may be spread on inner covers or placed in special bee-tight boxes atop several hives in isolated yards if they are from frames from disease-free colonies. Oxytetracycline may be fed to these colonies at the same time as a precautionary measure, provided that the whole operation occurs after the nectar flow has ceased.

Centrifugal separation — The beekeeper may uncap directly into a cappings spinner or whirl-dry, which separates much of the honey by centrifugal force. Cappings may also be augered or pumped into the spinner. The spinner may be a modified extractor with wire baskets to retain the cappings.

Wax press — Cappings may be pressed to remove much of the honey before further processing. Frames may be uncapped directly into the press, the cappings then pressed into a solid cake and the honey drained off.

The above four methods may leave a fair amount of honey in the cappings, which can then be removed during the subsequent melting process. The following methods call for heat to be applied to the cappings mixture; excess heat will certainly discolor honey and may damage the wax as well. Special care should always be taken to check and adjust temperatures.

Cappings melter — The cappings melter at its simplest separates wax and honey through warming, then melts the wax and drains wax and honey off through spigots at different levels. One type of melter has a heat source in the bottom to initiate separation and a source of overhead radiant heat to melt the wax. The honey is protected from overheating by the molten wax layer. If the melter is properly constructed and used, honey may be run directly into the sump. Regular checks must be made on the melter to ensure it is correctly adjusted and on the color of the cappings honey, as only a very small amount of discolored honey is needed to darken an entire tank. If darkened in the melter, honey should be kept separate. Wax is run into plastic wash tubs or other containers with tapered sides and allowed to harden into blocks, then removed and stored. An advantage of the cappings melter is that the honey and wax are separated and the wax melted all in one step. All other methods require initial separation and subsequent melting of the wax.

Copper, iron, monel metal, zinc and brass will discolor melted wax and should never be used in melter construction. Stainless steel is the material of choice; nickel and tin also appear to be safe construction materials. Steam heat should not be used in the cappings melter, being too hot for both honey and wax; hot water coils in the bottom of the melter are the safest means of heating the mixture.

Spin-float separator — The spin-float separator is an effective means of separating honey from wax and drying the cappings. The honey and wax from both the uncapper and extractor are continuously pumped through the heat exchanger to warm the mixture and thence directly into the separator, which separates the mixture using centrifugal force. Cappings from the separator are dry enough to be shovelled. This system works well with the type of uncapper which breaks cappings into small pieces rather than slicing them off the combs. The temperature of the mixture should be monitored to prevent damage through overheating.

RENDERING BEESWAX CAPPINGS

Cappings wax is clean, light in color and of higher quality than wax obtained from broken frames, old brood combs and scrapings, and the two should be kept separate for rendering.

If cappings are not processed in a cappings melter they may be melted in water, in a steam chest or in a solar wax melter. Whichever method is used, cappings containing honey should never be stored for any length of time in containers such as pails or drums for later processing, as the honey will eventually crystallize and the mixture will then be very difficult to remove. Sacks or plastic bags will be easier to manipulate.

Processing cappings in water — For the beekeeper with only a few kilograms of wax, it is feasible to melt the wax in an old pot on the stove. The pot is filled to about one quarter full of water. As the water heats the cappings melt and any honey and particulate matter dissolve in the water or sink to the bottom of the wax layer or into the water layer. The wax may then be left overnight to harden and the block removed from the

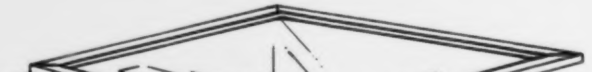


Figure 35A:
Solar wax melter (after Jaycox, University of Illinois).

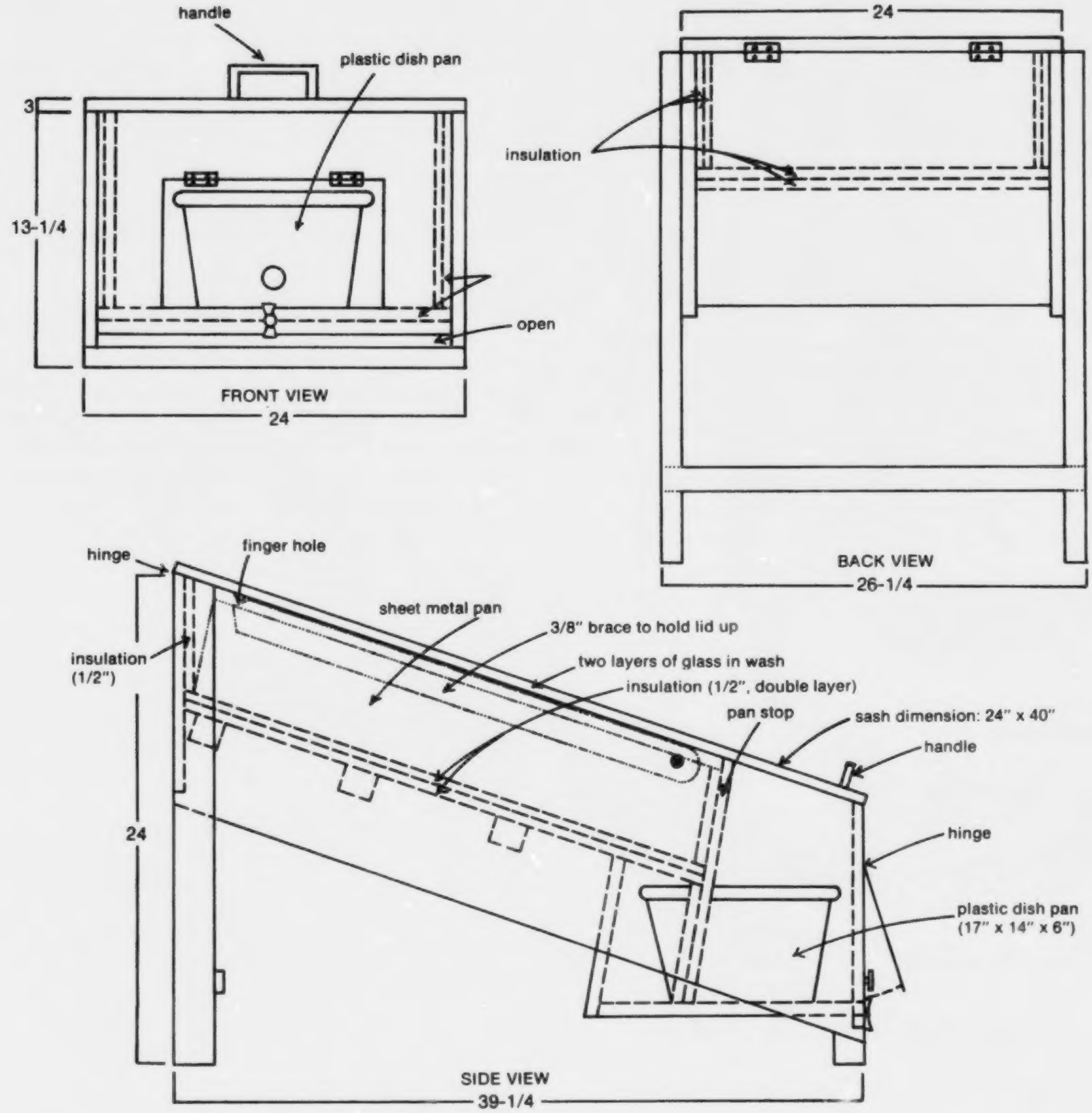

handle
plastic dish pan
3
13-1/4
open
FRONT VIEW
24
24
insulation
BACK VIEW
26-1/4
hinge
finger hole
sheet metal pan
3/8" brace to hold lid up
two layers of glass in wash
insulation (1/2", double layer)
insulation
(1/2")
pan stop
sash dimension: 24" x 40"
handle
24
hinge
plastic dish pan
(17" x 14" x 6")
SIDE VIEW
39-1/4

Figure 35B:
Solar wax melter (after Jaycox, University of Illinois).

pot, in which case the bottom of the wax block will require some scraping to remove the dirty layer. Alternatively, the melted wax may be ladled into containers. If a suitable melting pot is provided with a spout near the rim, once the wax is melted, boiling water may be added to bring the wax level up to the spout, thus decanting the wax into containers. Wax should never be melted over an open flame or on a stove without using water, as there is an extreme danger of fire.

The steam chest — Cappings may be melted in a chest using other than live steam. If live steam is used then the honey in the cappings cannot be salvaged; live steam may also cause some chemical alteration of the wax.

The solar wax melter — A solar wax melter (figure 35) is a glass-covered box, sloped in the direction of the sun and painted black inside and out for greater heat absorption. It can be used during the summer months to melt cappings, burr comb, scrapings and old combs, as well as to clean the wax off queen excluders. The hinged glass lid retains heat more efficiently if made with two panes separated by 1 - 2 cm. Weather-stripping between lid and box will help to retain heat as well as to keep the melter bee-tight. Insulation of sides and bottom will also help in heat retention. A sloping tray of galvanized metal, aluminum or stainless steel holds the wax: a removable basket of galvanized mesh or expanded metal may be used over the metal tray.

The tray should be 10-15 cm deep, and at least large enough to hold queen excluders. Wax and honey run down the tray through a coarse screen into a container such as a plastic dish pan placed under the edge. The screen prevents slumgum and unmelted wax from falling into the plastic pan. A layer of darkened honey forms under the wax, and this honey may be saved for spring feed if from disease-free colonies. Slumgum will accumulate in the basket especially when old combs are melted. If enough slumgum is accumulated it may be further rendered using a wax press or steam chests.

RENDERING BROOD COMBS

It is difficult to recover the wax from brood combs owing to the large amount of wax adhering to old cocoon material, propolis and pollen residues. Wax presses or steam chests are generally used to extract wax from both brood combs and slumgum. Many commercial beekeepers have their old brood combs and slumgum rendered commercially for a percentage of the recovered wax. The small beekeeper may wish to recover as much wax as possible using a solar wax melter and then place the remaining slumgum and cocoon residue in burlap sacks. If this mixture is soaked for several hours in cold water the cocoons and other foreign material are thoroughly wetted, and when the mixture is heated they do not then absorb the melted wax. Once heated, the sack is then agitated or squeezed to separate wax from the other matter. When cooled, the wax will harden on top of the water.

IX. MARKETING THE CROP

MARKETING HONEY

There are two major markets for the commercial beekeeper's honey crops, the Canadian domestic market and the export market. Per capita consumption in Canada is fairly constant at just under a kilogram per year. After filling domestic needs, about one-third of Canada's annual crop is available for export.

At the time of writing, the four countries which import over 90 per cent of Canada's export honey are the United States, West Germany, France and the United Kingdom, with the rest of the honey going to the Netherlands and other European countries, the Caribbean, and Japan. Canada produces much white honey which is in demand worldwide, both for consumer sales and for blending with darker honeys to satisfy customer preference for light honeys.

Other countries which are leading exporters of honey are China, Mexico, Argentina and Australia. Argentina and China produce lighter honeys and are in more direct competition with Canada than are Mexico and Australia, whose honeys are darker.

Some beekeepers choose to sell directly to buyers in the United States and overseas, generally working through a broker. As well, some of the honey sold in bulk to Canadian packers is destined for export as both bulk and packed honey. Developing an export market for honey takes time and experience, and can involve some risk to the beekeeper or broker. The beekeeper must be knowledgeable about the reputation of the buyer with whom he or she is dealing, as well as the honey grading regulations and tariffs of the country in question. Such problems as who pays the shipping costs and when payment will be made must be included in negotiations. Honey for export requires prior inspection and certification by the federal government.

On the domestic market the commercial beekeeper can market honey directly to the consumer or in bulk containers to honey packers. Direct sales include sales from the honey house or a roadside stand, farmer's markets, and sales to retail outlets.

Because of the large amount of honey produced and the relatively small population in most areas of the Prairies, direct sales account for only a small percentage of prairie honey. Beekeepers who are located near an urban centre may wish to market their honey directly. Before doing so they should be aware of provincial and federal regulations concerning honey sales (see the appendix).

Farm gate sales — Farm gate sales are those from the honey house, the place of residence or a farmer's market. Provincial Honey Regulations state that honey sold at such places must be labelled with the name and address of the beekeeper and the net weight of the honey. There are no requirements for standard container sizes or declaration of a grade or color classification of the honey.

Retail store sales — All honey which is sold on the retail market, i.e., not farm gate sales, must be done so in accordance with the Canadian Honey Regulations (appendix). A beekeeper who retails honey must be registered as a producer grader with Agriculture Canada, Dairy Fruit and Vegetable Division. Such registrations require that honey be packed in standard metric sized containers with the weight in kilograms or, if under 1 kilogram, in grams clearly marked on the label. Labels must also be marked with the word honey, the color classification and the grade of the honey as specified in the regulations. All labelling must be in both of Canada's official languages. The name and address of the beekeeper and the producer graders' registration number must also appear on the container.

Retail honey crossing provincial borders and honey which is exported comes under federal jurisdiction and must also be packed in a registered establishment.

If honey is purchased from other beekeepers and then packed for resale, the beekeeper's establishment must be registered as a packing plant. This certification is also available from Agriculture Canada.

Direct sales, whether within the province or not, require greater care in settling and straining honey than do bulk sales. However, sanitation in and around the honey house should be of high standard regardless of the destination of the honey.

Within Canada, there has been a gradual shift from east to west in honey production over several decades, and at the time of writing the three prairie provinces produce about 80 per cent of Canada's bulk honey. Most commercial beekeepers market their honey in 200 L drums to honey packers. In the prairie provinces beekeepers may sell to the Alberta or Manitoba Honey Producers' Co-operative, a member-owned organization marketing under the brand "Bee Maid", or they may sell to private packers across Canada. From 35-55 per cent of prairie honey is sold to the co-op, while a similar amount is sold to private packers. Membership in the co-op must be applied for. The co-op supplies barrels and picks them up when filled. An initial payment is made, with several subsequent additional payments and a final payment about 15 months later. With private packers terms will differ among packers and among beekeepers. Cost of transportation and drums must be taken into account: there may be quality differences if drums are exchanged. The beekeeper should make every effort to know the reputation of the packer with whom he or she is dealing, and terms of sale should be settled before the honey leaves the honey house. Payment is generally made in full within a certain length of time after the honey is moved. Payment in full may be more helpful than installation payments for new beekeepers with higher costs. The beekeeper must balance payment arrangements and risk in deciding how to market his or her honey.

Sideline beekeepers may have difficulty marketing their honey, having too much for direct sales and too little for bulk sales. They may wish to sell their honey to a local commercial beekeeper who will then market it along with his or her own product. Alternatively, they may try some retail marketing in local stores, farmer's markets, and roadside stands.

MARKETING BEESWAX

Most of the beeswax produced by the North American beekeeping industry goes to the cosmetics and pharmaceutical industries. Other major markets include the candle-making, industrial and beeswax foundation industries.

Many beekeepers save some or all of their beeswax for trade to beekeeping supply houses for foundation. Beekeepers who wish to market wax to other industries may find it easier to deal through a broker. Industries which buy beeswax usually require relatively small amounts of wax on a steady basis throughout the year, whereas the beekeeper generally markets all of his or her beeswax at one time.

X. FALL AND WINTER MANAGEMENT

At the end of the main nectar flow hives are reduced to two or three supers. If he or she has not already done so the beekeeper must now decide whether or not colonies are to be wintered.

ROBBING

At this time robbing situations can quickly develop. Colonies have large field forces which are no longer involved in collecting nectar and pollen, and which continue to search for food sources. Weaker colonies may be completely robbed unless preventive steps are taken. Any hive manipulations must be done as quickly as possible or when the bees are not flying, and exposure of honey and syrup must be avoided. If certain colonies are being "picked on", they may be moved or turned so that their entrances are facing in the opposite direction.

Since robbing is very effective in the spread of bee diseases, after the last honey pull oxytetracycline should be given to each colony whether it is to be killed or wintered.

PACKAGE OPERATIONS

Colonies should be reduced to two supers at the end of the main nectar flow. This will usually be in mid-August in northern areas and one or two weeks later in the south. It is best to kill the colonies fairly soon after the nectar flow is over in order to retain honey and pollen stores in the brood chambers for next year's packages. Large commercial operators generally begin to kill colonies right away in order to get everything finished in short order.

Once killed, bees are generally shaken or blown from the brood chambers in the bee yard. Hive equipment is then loaded onto the truck and returned to the storage area. Some time between the fall and the following spring, brood chambers must be prepared for the next season's packages, as outlined in section 5. This sorting may be done at the time of killing or sometime during the winter months if a heated area is available.

Some beekeepers prefer to hatch brood combs before storing equipment. This avoids having capped brood hatch in storage after the colonies are killed. Also, the following year's package bees which will not have the task of uncapping and removing dead brood. Combs containing capped brood are placed in supers and stacked on a few remaining live colonies. After one or two weeks these colonies are killed after the brood has emerged. NOTE: If there is any history of American foulbrood in the apiary this procedure is not recommended as it could serve to spread disease. Until they are killed these colonies should be medicated with oxytetracycline.

USING CALCIUM CYANIDE TO KILL HONEY BEE COLONIES

Calcium cyanide is presently registered in Canada for use in killing colonies. It is marketed in dust and granular formulations, the dust formulation being used by the beekeeping industry. Calcium cyanide reacts with moisture in the air to release hydrogen cyanide, a clear gas smelling of bitter almond, and leaves a residue of calcium hydroxide, a harmless dust. Hydrogen cyanide is *powerfully toxic*, to humans as well as to insects, acting to inhibit the supply of oxygen to body cells. A dosage as low as 200 parts per million will quickly kill a human, through inhalation, ingestion or through skin contact. For this reason beekeepers must be extremely careful in handling calcium cyanide. Symptoms of minor exposure are weakness, dizziness, headache, nausea, vomiting, unsteadiness of gait and a feeling of suffocation. Greater exposure will cause fainting, cessation of breathing and death. Normal functioning will return when exposure to the gas ceases, if death has not already occurred.

Calcium cyanide should be kept in its original container, clearly labelled, and stored in a locked or secure place vented to the outside. It should not be carried in truck cabs or left in car trunks for any length of time. Containers should be checked periodically for corrosion or breaks, and empty containers should be crushed and buried.

When using calcium cyanide in the field it is best not to work alone, and to work upwind of the chemical. Rubber gloves and safety goggles or respirators are recommended. Do not get cyanide dust on the skin or in the eyes. Wash hands and face between each yard, and change clothes as soon as possible after finishing for the day.

Hives are killed during non-flying conditions such as in cool weather or the early morning or late evening. Calcium cyanide should be used in accordance with the label directions: 12.5-25 g (1-2 tablespoons) of calcium cyanide are sprinkled on a paper plate or sheet of cardboard and slipped into the hive entrance. Once applied, entrances are blocked and the hives kicked or jarred to stir up the bees, then left for at least 30 minutes, afterwhich the hives are thoroughly aired out before removing from the field. This delay and ventilation allows the hydrogen cyanide to effect a complete kill and dissipate before the beekeeper must handle the hive equipment.

WINTERING HONEY BEE COLONIES

The races of honey bees used in Canadian beekeeping are of temperate origin and are adapted to a greater or lesser extent to survive a long cold winter by forming a cluster, and utilizing food stored during the summer to generate heat. Wintering colonies of bees in hives simply take advantage of the colony's natural inclination, and management techniques have been developed which complement the tendencies of the bee.

Wintering honey bee colonies is not a new idea. Before package bees were available wintering was a necessity, and much literature published in the early part of the twentieth century had to do with refinement of wintering techniques. The advent of the package industry changed Canada's beekeeping industry and wintering was no longer the norm in the prairie provinces, but over the past decade there has been an increasingly strong interest in wintering. Beekeepers who have committed themselves to wintering have done so for a number of reasons. Economically, production costs are somewhat lower for wintering operations despite extra sugar, labor and wintering costs. Buying package bees and boosters is considerably more expensive than operating wintered hives, as revealed in a recent study (see Appendix: Additional References). By importing packages each year the beekeeper is also importing any problems present in the colonies producing the packages; diseases such as AFB, EFB, nosema and chalkbrood may all be transmitted by adult workers. The possibility of importing other pest problems such as tracheal mites, Africanized bees or varroa mites, is also cause for concern. With wintering, beekeepers can make their own stock selection and eliminate stock which does not suit their needs and can become to some extent self-sufficient. Management of wintered colonies is spread over a longer time period. If managed correctly wintered colonies will produce more honey especially in the early part of the nectar flow. During later flows, for instance in August, package colonies can be as productive as wintered colonies.

There are several limitations to wintering bees outdoors on the prairies. Certain types of honey, such as canola honey, granulate in the combs and do not make good winter stores. Good locations for winter apiaries may be difficult to find, especially in areas where much of the land is treeless. Severe winter kill of colonies is always a possibility and beekeepers who winter their bees generally count on a 10 per cent reduction in colony numbers through starvation, queenlessness and spring dwindling. This figure may be as high as 30 per cent in the first year, as the beekeeper has put package stock into winter which is not necessarily well-adapted to winter survival. High winter mortality is in itself a form of stock selection. Hive equipment is used year-round, therefore its life expectancy is reduced. Spring management is more demanding with wintered than with package colonies. Comb sorting and culling must be done during the spring checks instead of after the field work is finished. Most importantly, wintered colonies must be requeened every one or two years, so the beekeeper must develop a method of regular requeening, and may find that queen-rearing is necessary to obtain the desired stock.

Proper timing is crucial to the success of wintering, whether indoors or outdoors. Colonies must be moved, fed and wrapped or moved inside well before the onset of winter. One cannot decide in mid-October to winter his or her colonies; by then it is too late for preparations, and chances of success are slim.

What to winter — Only healthy populous colonies with lots of young bees and proven young queens should be prepared for winter. A larger cluster will be more efficient at heat generation and will be able to maintain a larger brood area earlier in the spring than will a small cluster. Most colonies which have built up to high populations through the summer will be strong enough to winter well. Weak colonies and those which have queen problems are not as likely to survive the winter out of doors, and should be united with other colonies or destroyed. With indoor wintering there is more leeway: nuclei made up in mid-summer, for example, may be successfully wintered indoors in just one brood chamber.

There is some feeling among experienced beekeepers that the Carniolan and Caucasian races are better for wintering operations than is the Italian, although there is a wide range of variation within each race. Italian strains will winter well but may consume more feed than the darker strains, which winter in smaller clusters and with less food consumption.

Feeding colonies for winter — Feeding colonies at any time is a stressful situation, and the fall feeding is no exception. Colonies should be managed to minimize this stress as much as possible, to avoid undue disturbance and disease flare-ups. Keeping this in mind, there are three aims in fall feeding: to feed (a) as large a quantity per round as possible, (b) as quickly as possible, and (c) as thick a syrup as possible. Inner frame feeders, Boardman feeders and small pails or tins will not hold enough; a 15 kg feeder pail or a hive top feeder is recommended. Suitable feeder types are covered in section 5. Thick (2:1) syrup supplies more food in a given volume than does thin, and makes less work for the bees as well as for the beekeeper. The sugar syrup must be inverted, evaporated, stored and capped by the bees before the onset of cold weather, all of which takes time. Once cold weather arrives colonies take the feed much more slowly, if at all, hence feeding must begin in early September to ensure that colonies will have the necessary food stores for winter. Feeding is generally finished by early to mid-October in the north and late October in the south.

Bees do not freeze to death, they starve to death!

Oxytetracycline should be added to all syrup for fall feeding. The drug is then stored with the bee-manipulated syrup and will be effective when brood-rearing begins again. Fumagillin should be added to at least one round of feed. Feeding oxytetracycline and fumagillin is discussed further in section 12 and the Appendix, Recommendations for Feeding Antibiotics.

Hives should contain at least four to six combs of pollen or mixed pollen and honey. Usually pollen is abundant during the summer and is collected and stored around the brood nest. If a pollen shortage should occur, a protein supplement may be fed in early spring to boost brood-rearing.

OUTDOOR WINTERING

Colonies to be wintered outdoors must be located in sheltered apiary sites with access to early spring nectar and pollen flows (see Section 5, Spring Management). If moving is necessary it should be done before fall feeding begins to allow the bees time to recover from the stress of moving, as well as to save the beekeeper's back, if colonies are not palletized. Colonies should also be arranged in the desired groupings before feeding, and should be off the ground either on cleated bottom boards or on pallets.

Colonies in two brood chambers must weigh between 63 and 73 kg (140 and 160 lb). If in three boxes the total weight should be from 73 to 82 kg (160 to 180 lb). These weights generally ensure a food supply until the next spring's nectar and pollen flows begin.

An upper entrance is an important requirement for successful outdoor overwintering. The colony cluster gives off water vapor as it respires, which rises to the top of the hive and which must be allowed to escape. Otherwise this moisture condenses and freezes, forming an ice blockage between the frames. As the cluster moves into the upper super it will encounter this ice block and starve. By the time the beekeeper begins the first spring checks the ice will have melted and the beekeeper will wonder why the bees starved with a box of honey available. The lower entrance may not be used by the bees during winter; often it will be blocked with snow. It should be reduced to a very small size (e.g. 8 mm) or may be blocked off entirely.

An inner cover with a small entrance hole (7-8 cm x 1 cm) cut from the deep side of the rim and a feed hole in the centre can be used both for fall feeding and wintering (figure 14). Alternatively, year-round covers may be made from 19 mm (3/4") plywood cut to the dimensions of the super. These covers have 7-8 cm x 1 cm entrances dadoed on one side, and feed holes drilled in the centre which are plugged when not in use. The covers are turned over when the upper entrance is not required. The weight of the plywood and propolizing by the bees will keep the cover in place throughout the year. Painting both sides and edges or dipping the covers in wax is recommended for increased durability.

Although colonies can live through mild winters without added insulation, insulation will decrease colony food consumption and mortality. Insulation is therefore provided to temper the changes in ambient temperature, protect colonies from drafts and help conserve cluster heat, and allow more cluster movement within each hive. Insulation also keeps the hive cavity drier. Hives may be wrapped individually or in groups of two, four or more. Groups of four represent the most efficient use of insulation and of heat retention, with two sides of each hive being exposed and two sides being protected. If hives are grouped in larger numbers those with three protected sides tend to stay too warm, remaining more active through the winter and consuming more food.

Many insulative materials have been used for wintering beehives. Early reports cite leaves, sawdust, shavings and straw while more modern materials include fibreglass, fibrefill and styrofoam. Recently, hives have been arranged in groups of four and wrapped with paper backed fibreglass insulation and building paper. R-20 insulation is placed on top of the fourpack which is then covered with a common plywood lid. Upper entrances are provided through inverted inner covers and corresponding holes cut through the insulation and building paper. A 3" x 5" (75 mm x 125 mm) piece of ⅜" (9 mm) plywood with coinciding hole is nailed against the hive to push the insulation snugly in place around the top entrance. Insulation, building paper and lid are tied in place with twine, string, wire or tarp hooks (figure 36).

This method has proven successful when used in conjunction with proper fall management. However, from a handling perspective there are certain drawbacks. Exposed insulation causes skin irritation and can be deleterious to one's health if fibreglass particles are inhaled. Concern has been expressed that exposed fibreglass may possibly be restricted around foodstuffs in the future. The material is also clumsy to handle and the method labor intensive as the insulation and tar paper must be wrapped separately. Early spring inspections are also difficult as the exposed insulation tends to fall into the hive when the hive is opened. Furthermore, mice and skunks find the exposed insulation attractive for nesting, resulting in a shortened lifespan of the material. Because of these problems and the fact that paperbacked insulation in rolls is difficult to obtain, alternative methods have been sought. One such method is the construction of a wrap utilizing fibreglass batts totally enclosed in 6 mil black polyethylene. The wrap avoids any exposed insulation, consists of a single piece, is easy to handle, is relatively mouse resistant and is easy and economical to construct. The polyethylene protects the insulation from the elements and should greatly prolong the life of the wrap. Commercial beekeepers in Saskatchewan and Alberta have used the wraps successfully with results comparable to the above-mentioned building paper method.

R-12 fibreglass, 23" (58 cm) wide batts are placed on a 6-7 foot (2 m) wide sheet of 6 mil black polyethylene. One side of the sheet is folded over the other to completely cover the batts. A medium hot iron over aluminum foil or newspaper is then used to bond the overlapping polyethylene thus sealing in the fibreglass. The ends are sealed, leaving the corners open to allow air to escape. Templates are made to cut top entrances in the wrap during construction. A similar wrap can be constructed for top insulation using R-20 pink insulation or one can simply place pieces of two 15 inch R-20 batts inside a standard barrel liner for the top insulation. A common plywood cover and plywood top entrance boards are used as in the building paper method. For complete directions on the construction and utilization of this wrap, obtain Alberta Agdex 616-21, *A Polyethylene Insulated Wrap for Overwintering Honey Bee Colonies Out-of-Doors in Alberta (see Appendix).*

Mice and skunks can be a problem in colonies wintered outdoors. Precautions should be taken to prevent occurrence of mouse damage in hives and insulation and decimation of colony populations by skunks, as outlined in section 13.

INDOOR WINTERING

Colonies to be wintered indoors are usually fed with sugar syrup before being moved into the wintering building. As is the case for outdoor wintering, colonies should be fed beginning in early September to ensure gross weights of 55 - 59 kg (120 - 130 lb) for two-storey hives or 39 - 45 kg (85 - 100 lb) for one-storey hives.

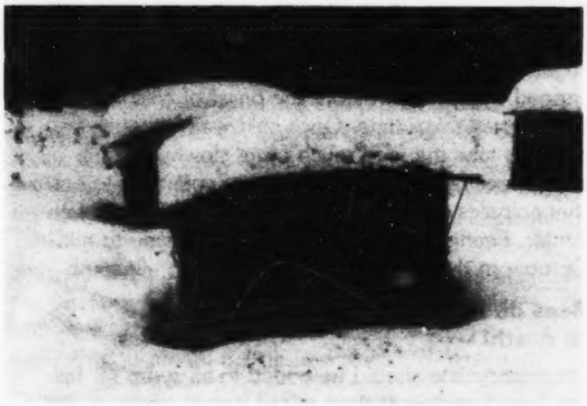
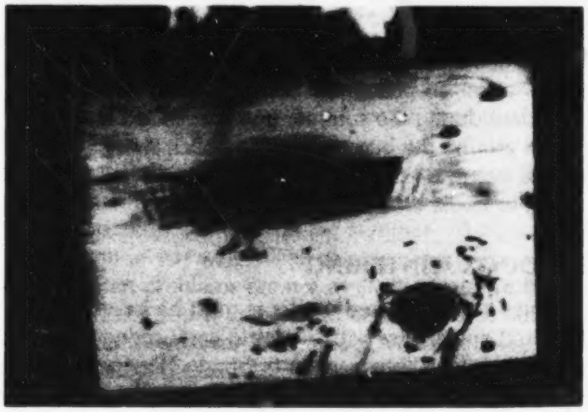


FIGURE 36 A & B.
Hives prepared for winter in insulated "four-pack" arrangement. (A) Hives are wrapped with fibreglass insulation and 6 mil polyethylene and have a common cover. (B) Plywood rectangles coincide with top entrances.



Once feeding has finished and the weather has turned cold, the hives are moved into winter storage. On the prairies, this typically occurs during late October or early November. Where hives are on pallets, moving them with forklifts may be accomplished quickly and with little disturbance to the bees. If hives are to be handled manually, however, greater time and labor will be required.

Ventilation principles of wintering buildings

There are several basic requirements for an indoor wintering facility; temperature control, air circulation, ventilation and light exclusion. Before constructing or modifying a building for indoor wintering, beekeepers should visit other indoor wintering facilities and should contact their apiculture office for updated information on technology changes.

Honey bee colonies give off heat, water vapor and carbon dioxide (CO_2). The ventilation system removes these by-products by exhausting storage air and replacing it with outdoor air. The temperature, relative humidity and gas composition of the storage air is controlled within a range which is most comfortable for the bees.

In the late fall and early spring when outdoor temperatures are mild, the heat produced by the bees is greater than the amount required to maintain the storage temperature. This excess heat is removed by exhausting warm storage air and replacing it with cool outdoor air. Exhaust fans controlled by thermostats are used to exhaust this heat. Under these mild conditions, the ventilation provided to control temperature is more than adequate to remove the water vapor and CO_2 produced by the bees. No special provision to control humidity is required.

When the outdoor temperature is very cold, all the heat produced by the bees is required to maintain the inside storage temperature. As a result, the thermostatically controlled exhaust fans seldom run. However, the bees continue to produce water vapor and CO_2, and unless these by-products are removed, they will continue to build up and will eventually cause problems. A low level of continuous ventilation is therefore used to control water vapor and CO_2.

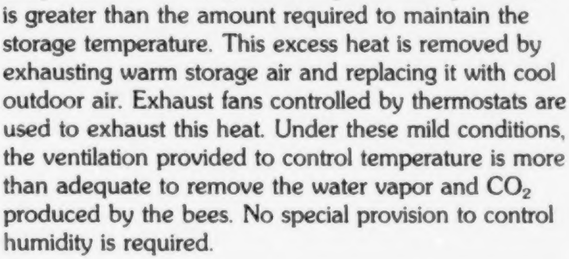


Figure 37:
Winter ventilation for overwintering hives

Figure 37 illustrates the heat and moisture balance for a wintering building under typical winter conditions. Each colony produces approximately 3 to 10 grams per hour of water vapor and 8 to 28 watts of heat. Under normal winter conditions the heat and moisture production are at the lower end of these ranges.

Moisture is removed by replacing storage air with outside air. Even though the relative humidity of cold outdoor air is high when it is introduced into the building, when it is heated to the storage temperature its water holding capacity is increased. For example, 1 kg of outdoor air at -25°C and 100 per cent R.H. contains only 0.4 grams of water vapor. When this same kilogram of air is heated to 5°C however, at a relative humidity of 60 per cent (a desirable storage humidity) it is capable of holding 3.4 grams of water vapor. Thus for each kilogram of storage air exhausted at 5°C and 60 per cent R.H. and replaced with outdoor air at -25°C and 100 per cent R.H., there is a net loss of 3.0 grams of water vapor. Based upon typical conditions, a minimum continuous ventilation rate of 0.25 L/s per hive is required in winter to remove the water vapor produced by the bees.

Continuously exhausting warm storage air and replacing it with cold outdoor air removes a large amount of heat from the storage. To heat the minimum ventilation rate of 0.25 L/s per hive from -25°C to 5°C requires approximately 13 watts of power.

In addition to the heat lost through the ventilation system, heat is also lost by conduction through the building components. This loss is approximately 4 watts per hive at -25°C. Therefore, the total building heat loss is approximately 13 plus 4 or 17 watts per hive. However, the colonies typically produce 10 to 12 watts of heat per hive. The difference between the two heat flows is approximately 5 to 7 watts per hive and must be supplied by a supplementary heating system.

Fan forced electric heaters are normally used to provide this heat. For design purposes they should be sized on the basis of 10 watts per hive. This allows for some factor of safety, since the heat production rate of the bees can vary considerably. The electric heaters are thermostatically controlled to maintain the desired storage temperature.

A problem may occur in late spring prior to removing the bees from storage. Outdoor air temperatures at this time of year can often rise to 15°C or more. It therefore becomes difficult to use outdoor air to maintain storage temperatures of 4 to 7°C. The approach of most beekeepers has been to use high airflow rates, maintaining the storage within a few degrees of the outdoor temperature. Since these periods usually last only a few hours, this method has proven relatively successful. It seems that the bees can tolerate storage temperatures as high as 15°C for a short period, provided they have a good supply of fresh air. Recirculating a high airflow is also important since it helps to remove the heat from the hives.

Design recommendations

1. Building Size

The interior building area normally varies from 0.25 to 0.3 m^2 (2.7 to 3.2 ft^2) per hive, allowing from 0.7 to 0.9 m^3 per hive (24 to 30 ft^3 per hive). Loading densities within this range allow plenty of room for air to circulate. Though higher loading densities are physically possible and would reduce building costs, beekeepers who have tried this frequently have had more problems wintering. It appears that the extra volume of air per hive in a larger room moderates temperature fluctuations and permits better air circulation.

2. Building Construction

Practically any building type or shape can be used for wintering bees. Insulation in the walls and ceiling should be equivalent to RSI 3.5 and RSI 5.0 respectively. The foundation should be insulated with 50 mm (2 in.) of polystyrene insulation.

3. Ventilation System

The amount of heat and moisture produced by the bees can vary widely. Feeding methods, storage temperature, type of bees and many other management factors all affect the rate of heat and moisture production. Ventilation and heating recommendations (table 5) are therefore based on "average" conditions and can be expected to provide a good storage environment.

Storage relative humidities typically range from 50 to 70 per cent. Ventilation rates within the guidelines given in table 5 will normally result in humidities within this range.

Most wintering buildings on the prairies use a series of exhaust fans in combination with a recirculation fan and a polyethylene duct distribution system (figure 38). Intake air is admitted through an adjustable opening near the recirculation fan. This air is mixed with recirculated room air and distributed by the polyethylene duct (figure 39). The recirculation fan and polyethylene duct ensure that uniform conditions are maintained throughout the room. The airflow past the hives increases heat transfer from the hives. This cooling effect is especially important after a temporary warm period.

Livestock building ventilation fans are readily available and are quite satisfactory for honey bee wintering buildings.

A two-speed recirculation fan is often used. It can be operated on low speed during the colder months when a minimum of fresh air is introduced and can be switched to high speed when cooling becomes more critical.

A continually running exhaust fan (Step 1) provides moisture control in very cold weather. As the outdoor temperature increases, Steps 2, 3 and 4 are progressively turned on by thermostats as additional cooling is required. The heater thermostat controls the minimum temperature and is set at the lowest desired temperature, normally approximately 4°C. To ensure that the Step 2 fan does not run when the heater is on, the setting between the heater and Step 2 thermostats should be approximately 3°C. The fan thermostats are then set in steps with a difference of approximately 2°C between steps. Mounting the thermostats side by side, preferably in the centre of the room, is also important to ensure proper sequencing of the heater and fans. Thermostats should not be located in the path of air from an inlet, doorway or heater.

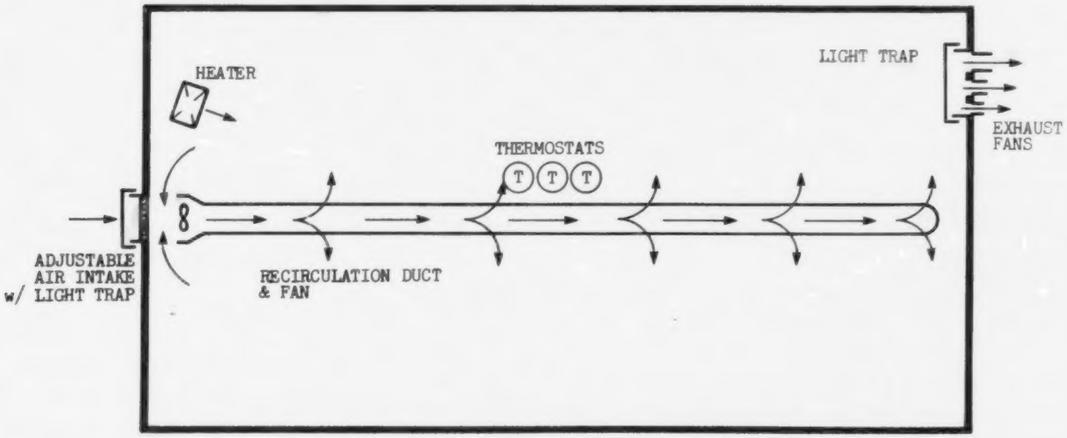


Figure 38:
Ventilation system for overwintering hives

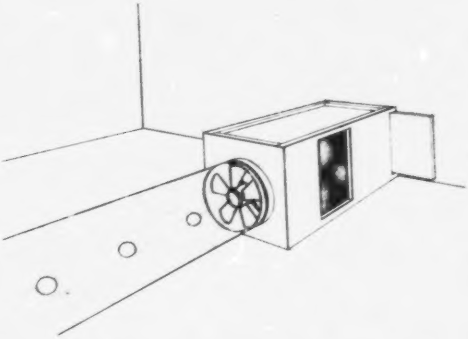


Figure 39:
Air mixing chamber

TABLE 5
VENTILATION RECOMMENDATIONS

	Fan Capacity (L/s/hive)	Total Capacity (L/s/hive)
Step 1 (minimum, continuous)	0.25	0.25
Step 2	0.50	0.75
Step 3	1.00	1.75
Step 4	3.25	5.00
Recirculation System		5.00

Intake area (adjustable) - 10 cm^2/hive maximum to 0.5 cm^2/hive minimum
Heater capacity - 10 watts/hive

The proper distribution of air in the building is provided by the polyethylene duct recirculation system. As a result, the location of the exhaust fans is not critical. Locating all the fans at one end of the building may be more convenient and cheaper to install and will not affect air distribution.

Smaller storages (500 colonies or less) require very low airflow rates. It is often difficult to find a suitable fan in the size range required. Over-ventilating with too large

TABLE 6.
VENTILATION DESIGN EXAMPLE FOR 100 HIVES

I FLOOR SPACE - Approximately 25 m^2

II FANS

	RECOMMENDED AIRFLOW (L/s)					ACTUAL AIRFLOW (L/s)	
	Fan Capacity	**Total Capacity**		**RECOMMENDED FAN***		**Fan Capacity**	**Total Capacity**
Step 1	25	25		BF-8, on 20%	SAME FAN	30	30
Step 2	50	75	ONE STEP	BF-8		140	140
Step 3	100	175					
Step 4	325	500		BF-10		235	375

III RECIRCULATION DUCT – Airflow required: 500 L/s
Recommended fan: BF2S-12
Poly tube: 380 mm diameter × length of room.
40 outlet holes, 50 mm diameter required.

IV INTAKE AREA – 0.1 m^2 maximum, adjustable to 0.005 m^2 minimum.

V HEATER SIZE – 1500 watts.

* All fan models refer to Hurst Equipment Ltd.

TABLE 7.
VENTILATION DESIGN EXAMPLE FOR 300 HIVES

I **FLOOR SPACE** - Approximately 75 m^2

II **FANS**

	RECOMMENDED AIRFLOW (L/s)				ACTUAL AIRFLOW (L/s)	
	Fan Capacity	**Total Capacity**	**RECOMMENDED FAN***		**Fan Capacity**	**Total Capacity**
Step 1	75	75	BF-8, on 50%	SAME FAN	70	70
Step 2	150	225	BF-8		140	140
Step 3	300	525	BF-10		235	375
Step 4	975	1500	BF-16		1240	1615

III **RECIRCULATION DUCT** – Airflow required: 1500 L/s
Recommended fan: BF2S-16
Poly tube: 600 mm diameter × length of room,
100 outlet holes, 50 mm diameter required.

IV **INTAKE AREA** – 0.3 m^2 maximum, adjustable to 0.015 m^2 minimum.

V **HEATER SIZE** – 3000 watts (3 kW).

* All fan models refer to Hurst Equipment Ltd.

TABLE 8.
VENTILATION DESIGN EXAMPLE FOR 500 HIVES

I **FLOOR SPACE** - Approximately 125 m^2

II **FANS**

	RECOMMENDED AIRFLOW (L/s)			ACTUAL AIRFLOW (L/s)	
	Fan Capacity	**Total Capacity**	**RECOMMENDED FAN***	**Fan Capacity**	**Total Capacity**
Step 1	125	125	BF-8	140	140
Step 2	250	375	BF-10	235	375
Step 3	500	875	BF-12	500	875
Step 4	1625	2500	BF-18	1745	2620

III **RECIRCULATION DUCT** – Airflow required: 2500 L/s
Recommended fan and poly tube:
Option 1: one BF2S-20 fan with 600 mm poly tube, 140 - 50 mm holes.
Option 2: two BF2S-16 fans wiuth 600 mm poly tube, 100 - 50 mm holes.

IV **INTAKE AREA** – 0.5 m^2 maximum, adjustable to 0.025 m^2 minimum.

V **HEATER SIZE** – 5000 watts (5 kW).

* All fan models refer to Hurst Equipment Ltd.

a fan wastes energy and causes low relative humidities in the storage. One way to provide a small minimum airflow is to use one fan for both Step 1 and Step 2 ventilation. The fan is sized for the Step 2 rate, and is operated intermittently by a timer to achieve a suitable Step 1 rate. For example, an adjustable 10 minute cycle timer set to run ON 3.3 minutes every 10 minutes provides a Step 1 rate of 1/3 rated fan capacity and a Step 2 rate of full fan capacity.

The recommended air inlet size is 1 m^2 for every 5,000 L/s airflow. An inlet which is too small will restrict the exhaust fans and cause reduced airflows. Too large an opening during cold periods will allow heat to flow out of the building under minimum ventilation. The maximum ventilation rate, Step 4, is approximately ten times the Step 1 rate. This requires the intake to be fully adjustable from maximum to minimum. The intake should be located close to the recirculation fan so fresh air is well mixed and evenly distributed as it enters the storage.

TABLE 9.
VENTILATION DESIGN EXAMPLE FOR 1000 HIVES

I FLOOR SPACE - Approximately 1250 m^2

II FANS

	RECOMMENDED AIRFLOW (L/s)			ACTUAL AIRFLOW (L/s)	
	Fan Capacity	**Total Capacity**	**RECOMMENDED FAN***	**Fan Capacity**	**Total Capacity**
Step 1	250	250	BF-10	235	235
Step 2	500	750	BF-12	500	735
Step 3	1000	1750	BF-16	1240	1975
Step 4	3250	5000	BF-20	2310	4285

III RECIRCULATION DUCT – Airflow required: 5000 L/s
Recommended fan: two BF2S-20
Poly tube: two 600 mm diameter × length of room.
140 outlet holes each, 50 mm diameter holes.

IV INTAKE AREA – 1.0 m^2 maximum, adjustable to 0.5 m^2 minimum.

V HEATER SIZE – 10 kW.

* All fan models refer to Hurst Equipment Ltd.

4. Light

The storage room should be built to exclude as much light as possible. Excessive light promotes bee activity and makes storage much more difficult. This is particularly true in late spring when outdoor temperatures are warm and the bees sense that spring is at hand.

White light bulbs should be replaced with red ones, as bees cannot "see" the lower red rays of the color spectrum. This will allow one to work within the storage with little disturbance to the bees.

The most difficult place to exclude light is at the air intake and fan openings. Several types of light traps are used. The principle of most is to force the ventilation air to make several right angle turns. A common problem is that discharged air from the fan is often forced to make an abrupt sharp turn. As a result, the fan operates at a higher pressure and a considerably

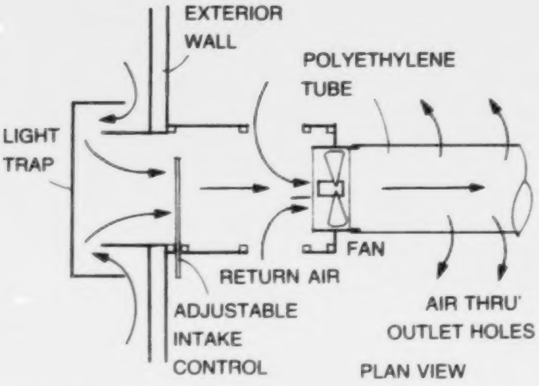


Figure 40.
Light trap.

reduced airflow. Figures 40 and 41 show a design which effectively eliminates the light and causes minimal restriction for the fan. This trap should be installed on the inside of the building since it will affect the fan performance less than if it is installed on the discharge side of the fan. Painting the interior surface of the light traps a flat black minimizes reflection, which helps to exclude light.

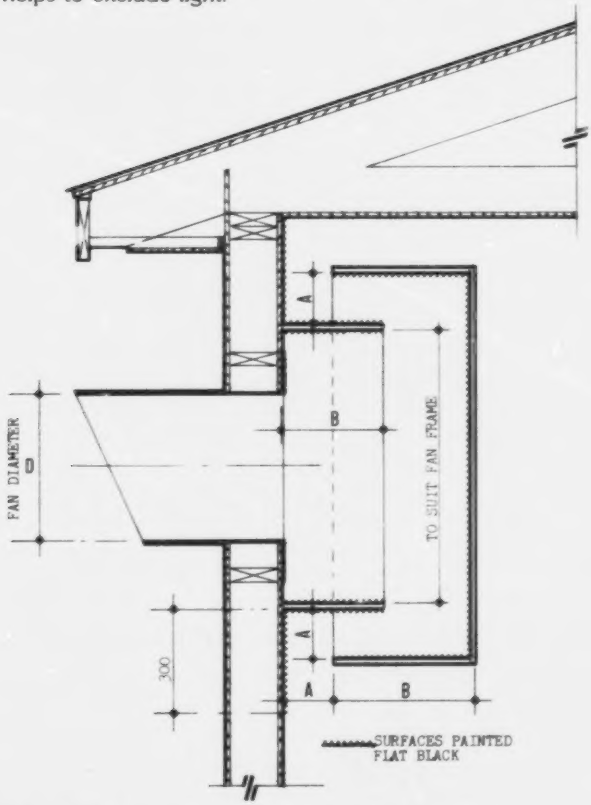


FIGURE 41.
Light trap and dimensions to use for fans of varying diameter.

Hive arrangement

Hives should be stacked in rows perpendicular to the air duct, with the rows spaced about 1 m apart to facilitate air movement.

Storage room floors should be swept periodically to dispose of dead bees. The dust caused by crushing the dead bees underfoot can often aggravate respiratory problems for the person(s) working in the building. However, sweeping should be done only when required to avoid constantly distrubing the colonies.

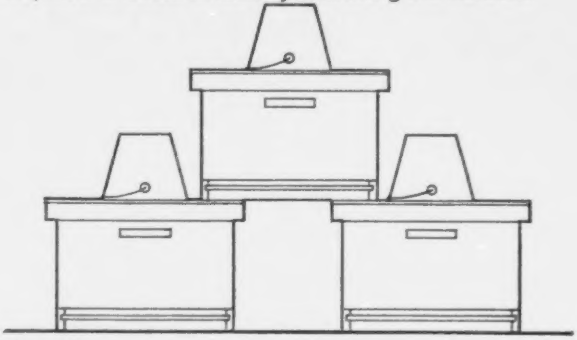


Figure 42.
Gravity feeders.

Feeding colonies indoors

At times it may become necessary to feed bees sugar syrup while they are in storage. Frequently used methods include gravity feeders, Boardman feeders and plastic honey containers (500 g size). To use honey containers, four or five small holes (3 to 4 mm in diameter) are punched on one side of each container near the top rim. After the containers are filled with syrup and the lids fastened, they are placed inverted on the bottom board with the holes facing the hive entrance.

Indoor feeding may also necessitate a modified hive stacking arrangement. A staggered or "off-set" stack which allows access to the top of each hive is required if gravity feeders are to be used (figure 42). If feeding is to be done through the entrance, the hives may be stacked directly on top of each other.

FAN DIAMETER (mm)	DIMENSIONS (min)	(mm)
"D"	"A"	"B"
200	25	75
250	38	115
300	64	200
400	100	300
450	125	375
500	150	450

* Based on one light trap per fan open on four sides

XI. THE QUEEN

NATURAL REQUEENING

The role of the queen in brood production and colony cohesion has already been mentioned (see section 1). Left to its own devices a honey bee colony will initiate production of new queens whenever the amount of "queen substance" available to the colony falls below a critical level.

The anatomical and behavioral differences exhibited by adult workers and queens (which are both female) result from both quantitative and qualitative differences in the feed that each receives during larval development. Larvae that are being reared as workers receive a surplus of food only up to about 2.5 days after hatching. After approximately 2.5 days the worker larvae are fed the minimum required for their development.

The food which is fed to larvae being reared as queens is commonly referred to as "royal jelly". One of the substances in royal jelly which affects the development of the larvae is the common insect hormone known as juvenile hormone. Research has shown that female larvae receiving juvenile hormone throughout their development will develop queen characteristics, whereas female larvae that do not receive this hormone throughout their development will develop into workers.

A honey bee colony will raise queens naturally under three basic circumstances or conditions:

Emergency — Emergency queen rearing occurs when a colony suddenly becomes queenless as a result of the queen dying or otherwise being removed from the colony. When this occurs, the colony begins feeding large amounts of royal jelly to a few selected existing larvae in worker cells. The colony is thus able, under "emergency conditions", to use the fertilized eggs in the worker cells as a source of replacement queens. This type of queen rearing typically shows up in the colony with the "peanut shaped" queen cells hanging down from the face of brood comb.

Supersedure — This occurs when the existing queen begins to fail, usually as a result of aging, injury or disease. Under any of these curcumstances, the colony will usually rear a replacement queen either from larvae in worker cells or larvae in queen cells.

Swarming — When a colony becomes large or congested in its current living space, queens will be reared in specially prepared swarm cells. Before these new queens emerge, the old queen will leave the colony taking with it a portion of the existing adult bee population. One of the new queens will normally take over as the queen of the "parent" colony. Swarm cells are typically located around the peripheries of the brood comb and along the bottom bars of the frames (figure 43).

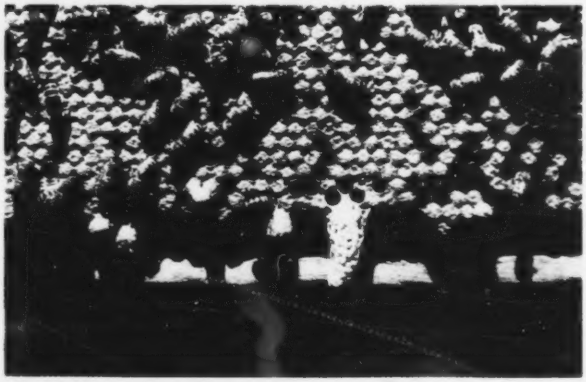


Figure 43.
Swarm cells. Queen cells occurring on the bottom of frames usually indicate that the colony is preparing to swarm.

Mating of queen honey bees takes place aerially outside of the hive. It is generally believed that the queen takes one to several mating flights during the first week after emerging as an adult. During these mating flights the queen flies from the hive and releases a chemical attractant (pheromone) which assists drones in locating her. After mating with one or several drones the queen returns to the hive and may or may not go on another mating flight before beginning to lay eggs. Usually, once a queen has started laying she will not go on any more mating flights. Therefore, continued egg fertilization is dependent on the quantity of spermatoza that was acquired and stored in a specialized organ, the spermatheca, during the first few weeks of the queen's adult life. On average, queens produce fertilized eggs from one to three years but individual queens may produce fertilized eggs for a shorter or longer time.

If the weather is not conducive to mating when the virgin queen is physiologically ready, after about three weeks she may begin to lay unfertilized eggs, which then develop into drones. Drone-laying also occurs when a queen has depleted her stock of sperm. A mated queen in prime condition can lay both fertilized and unfertilized eggs at will, depending on the size of the cell she is laying in, by using her front legs as calipers and reacting accordingly. A drone-laying queen can immediately be noticed by the bullet shaped cappings on all of her brood, including the worker cells which have been built out by workers (figure 44). The colony will try to supersede the queen in both cases, but if only unfertilized eggs are present supersedure will not be possible, and a queenless condition will result. A queenless colony is immediately noticeable to the experienced beekeeper by its peculiar buzzing, described as a roaring sound. In addition, the workers in a queenless colony are usually agitated and run about on the frames, often with their wings spread. A further check will show a lack of eggs.

Queenless colonies and colonies with drone-laying queens may be requeened using one of the slow release methods described below. The old drone-laying queens must first be destroyed or the new queen will not be accepted. Very weak colonies are better off united with queenright colonies.

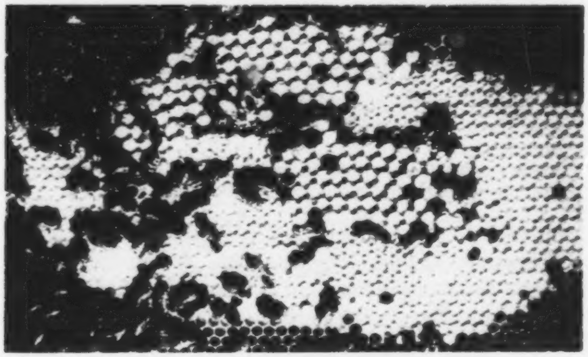


Figure 44.
Symptoms of a drone laying queen indicated by drones developing in worker sized cells. Symptoms appear as domed or "bullet" shaped cappings raised above comb surface.

LAYING WORKERS

When a colony is without a queen the inhibitory effect of the queen substances on worker ovary development is absent, and one or several workers may begin to lay eggs. The presence of many eggs deposited on the sides of cells in a disordered arrangement, some upright and some lying flat, signifies the presence of laying workers, the abdomens of which are too short to reach to the ends of the cells. This laying pattern should not be confused with that of a queen in prime condition held back from capacity by too small a cluster of bees; often such a queen will lay more than one egg in a cell, but these eggs are all deposited in the ends of each cell in an orderly manner. Since workers cannot mate, their eggs will develop into drones, usually small in size from being raised in worker cells and from undernourishment. Once a queenless colony has laying workers, requeening will generally be unsuccessful and the beekeeper is better off shaking the bees in front of another colony or on the ground away from other hives and letting them drift to other colonies in the yard.

REQUEENING AS A MANAGEMENT TOOL

Wintered colonies should be requeened every one or two years as a part of colony management. Without regular requeening, the beekeeper ends up with a proportion of his or her colonies not operating at full capacity because of older and failing queens.

Allowing colonies to requeen themselves through supersedure and emergency queen rearing will often result in some colonies dying as a result of queen failure in the winter and others not reaching their maximum populations in the summer because of queen failures during the spring buildup period.

Some beekeepers prefer to requeen only those colonies which they notice need requeening, however, for optimum overall control of queen quality and productivity, the beekeeper should requeen at least 50 per cent of the colonies each year.

Colonies may be requeened at any time during the spring and summer seasons. The pre-flow period best lends itself to requeening, as brood chambers are being checked regularly in any case. Post-flow requeening can be just as successful in terms of queen acceptance but will take more time, as colonies are very strong and old queens are hard to locate. There is also the danger of inciting robbing at this time of year.

METHODS OF QUEEN INTRODUCTION

To increase the likelihood that a queen will be accepted, colonies should be queenless for 3-5 days before a new queen is introduced. The queen to be introduced should be confined alone in a cage so that the bees cannot injure her but will be able to feed her through the screen while they are becoming acquainted with her presence in the hive.

New queens should be on hand when the colonies are unwrapped or moved outdoors when the first spring checks are made in April and May. Colonies which are strong but queenless, or which have a failing queen as evidenced by poor brood pattern, drone brood in worker cells, and a lack of brood, should be requeened immediately.

1. Queens can be confined alone in a screened cage with the exit opening filled with enough queen cage candy so that the workers will take one or two days to eat their way into the cage to release the queen.
2. The queen can be held under a shallow push-in cage made of 3 mm wire cloth, the edges of which are pressed lightly in the comb (figure 45). Some cells of honey and emerging brood should be included with the queen. This cage should be removed in about three days with as little disturbance as possible.

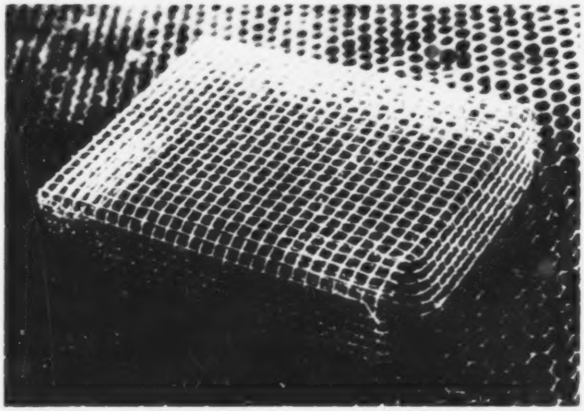


Figure 45.
Push-in cage for queen introduction. Cage is placed over emerging brood and entrance is plugged with candy.

3. The queen can be released directly with a light spray of vanilla extract (or some other aromatic substance) and sugar syrup. This can be accomplished by placing the queen on the face of a frame among the workers and then immediately spraying the queen and surrounding workers with a light mist of the vanilla/sugar syrup mixture. The spray apparently masks any foreign odors on the queen which may cause the workers to reject her. By the time the bees have cleaned up the spray the queen is usually accepted. This method works best when the honey bee colony has been queenless for at least 3-5 days.

BANKING QUEENS

When a large order of queens arrives and the beekeeper cannot use them all right away he or she may wish to keep them in a queen bank. This is a strong single storey queenless colony with a high proportion of young bees and plenty of pollen and honey or syrup. A special holding frame for the cages is constructed with support and holding bars to contain two or three tiers of cages. The attendant workers are removed from each cage, and corks are left in each end of each cage. Cages are then placed in the holding frame, candy down, and the holding frame is placed in the queenless colony. The young workers will look after most or all of the queens. The population must be replenished periodically with young workers. The subsequent performance of banked queens generally falls off in proportion to the length of time stored.

QUEEN CAGE CANDY

The candy used in queen cages can be made from icing sugar and corn syrup, using enough icing sugar that the candy becomes stiff and does not stretch. A drop of glycerine will ensure the candy does not dry out.

QUEEN REARING

Queens may be reared in late spring and summer, when nectar and pollen are abundant and colonies are strong, with plenty of young bees for wax-building and royal jelly production.

Whether the beekeeper wishes to rear only a few queens for his or her own use or enough queens for sale to other beekeepers, the basic principles of queen rearing remain the same. Breeder queens must be chosen which have the desired traits; young larvae must be obtained from these queens and placed in cell-building colonies primed to feed and care for developing queens; once hatched, queens must be cared for while maturing, mating and beginning to lay.

Any beekeeper interested in rearing queens should first consult the recommended references included in the appendix, which outline queen rearing in detail.

Using naturally-produced queen cells — If only a few queens are needed, the beekeeper may wish to use queen cells from colonies which are swarming, superseding, or queenless.

Swarming colonies are usually at their peak, with ample food stores and many young bees, and thus are able to raise well-fed queens. The beekeeper should choose the largest swarm cells from a colony with desirable characteristics, carefully cut the capped cells from the comb, and either place the cells in other colonies which have been dequeened or in mating nuclei. The main disadvantage in using swarm cells is in the possible perpetuation of the swarming trait.

Supersedure cells may also be used, if produced at the right time of year when a colony is in the peak of condition.

The beekeeper may raise queens by simply removing the queen from a colony and cutting its queen cells 10-11 days later. Variations on this method lead to greater control by the beekeeper on the process of queen rearing, by choosing breeder queens and giving their eggs to queenless cell builders as outlined below.

Breeder colonies — The breeder queen will be the mother of the new queens, and should therefore possess all of the traits which the beekeeper wishes to retain in his or her stock. Characteristics preferred by most beekeepers are a gentle temper, good wintering ability, and good honey production. Other characteristics include disease resistance, lack of a tendency to propolize, compactness of the brood nest, and desirable storage patterns. If this queen is to be used as the breeder queen for any length of time she is confined to a single super or to a nucleus. The breeder colony is provided with frames of capped and emerging brood and uncapped honey, and is fed continuously with a thin sugar syrup and pollen frames or supplement. A frame of foundation may be added to occupy bees of wax-secreting age. Young bees or emerging brood are added at least once a week. The queen is given an empty comb to lay in, generally a good-quality dark worker comb if grafting is to be done, or a light comb if cells are to be raised in and cut from this comb. On the third day after laying, these eggs begin to hatch and from 12 to 24 hours later are of the correct age for use by the beekeeper in grafting or transfer to cell building colonies. A new empty comb can then be given every four days. Alternatively, the queen may be given a new comb each day by confining her in a frame-sized cage of queen excluder material. The comb of freshly-laid eggs is then placed outside the excluder or in an incubator colony until the eggs have hatched and the larvae are 12-24 hours old.

Cell building colonies — Cell building colonies are those which receive the young female larvae and which raise them into queens. The cell building colonies may be queenright, but are more commonly queenless. Commercial beekeepers use a combination of queenless cell starters and queenless or queenright cell builders or finishers, the former receiving the newly grafted larvae and the latter receiving them 24 hours or more later.

In order to raise large, well-fed queens the cell building colonies must be very strong and crowded, with many young bees and drones and ample nectar and pollen: in short, cell builders bear a close resemblance to colonies which have the swarming impulse. They are prepared in the following manner: the queen is removed from a strong two or three storey colony and the bees shaken into one or two boxes, about a week before the colony is to be used. The colony is carefully checked for queen cells a week later or the day before it is to be used, and these cells are destroyed. The cell builder should hold frames of pollen and honey, capped and emerging brood, empty frames and a frame of foundation, which will occupy the wax-secreting bees. At least one or two frames of brood are added each week to keep up its strength, and young adult bees may be added as well. The cell builder is continuously fed with sugar syrup and frames of pollen throughout the queen-rearing period.

Rearing queens without grafting — The breeder queen is given an empty worker comb, preferably light in color, for egg-laying. When the eggs begin to hatch, about three days later, this comb is transferred to the cell building colony, prepared nine days earlier as outlined above. Two days later the comb is checked for queen cells and those present are marked by inserting a small nail into the comb above each cell, being careful not to damage the cells. About a week later the comb is checked again and any unmarked cells are destroyed, thus ensuring that queens are produced only from younger larvae. No later than nine or ten days from the comb's introduction to the cell builder, the comb is removed and the cells are carefully cut from the comb and placed in mating nuclei or previously dequeened colonies. The queens will emerge in two or three days and with good weather will be mated and laying within two weeks.

Other methods of rearing queens without grafting involve more manipulation and cutting of the comb, and are outlined in references in the appendix. Some of these methods can be used successfully in rearing large numbers of queens.

Rearing queens by grafting — This system is usually used for large scale queen rearing, and involves grafting, or transferring larvae of uniform age from worker comb to queen cups, which are previously prepared and attached to the removable bars of a cell-holding frame (figure 46). Breeder and some combinaton of cell builder, starter and finisher colonies are used. Queens can be reared for several weeks by following an orderly, day to day schedule.

Queen cups are prepared by constructing cell dipping sticks made from lengths of 9.5 mm dowelling, rounded and smoothed at one end with sandpaper. Size may be tested by fitting the rounded end into a natural queen cup. A series of these cell dipping sticks may be made up and attached to a strip of wood or a single stick may be used alone. Cell cups are formed by dipping the forming sticks into cold water, then into

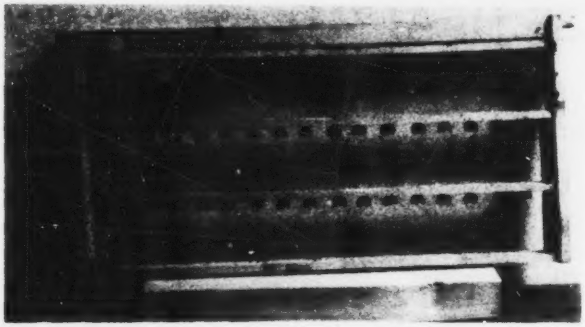


Figure 46.
Cell bar holding-frame with 3 cell bars and queen cups.

melted wax to about 1 cm, allowing this coat to harden, and dipping several more times, each time to a shallower depth. After immersing in cold water the wax cup is removed with a gentle twist. About 15 queen cups are fastened to each cell bar with melted wax. Commercial queen cups are also available.

The grafting room should be a least 24°C and high in relative humidity to prevent dehydration of the young larvae. A fluorescent table lamp gives satisfactory lighting without giving off heat. The breeder colonies and cell builders should be located nearby. Alternatively, grafting may be done in the apiary in the front seat of the truck if adequate relative humidity is maintained.

Grafting can be done with a variety of tools and with experience each beekeeper will find one which is most suitable. Commercial grafting tools are available. Some beekeepers flatten and sand the bent tip of a piece of copper wire for grafting, while others may find that fine sable-hair paint brushes work well.

Before grafting, cell bars should be prepared and the queen cups primed with a 50 per cent water: royal jelly solution, if desired, both to prevent desiccation and to aid in floating the young larvae off the grafting tool. A frame containing newly-hatched larvae is taken from the breeder or incubator colony to the grafting room. The light should be adjusted so that larvae are easily visible. The grafting needle is slipped under each larva which is then lifted from the cell and transferred to the queen cup, where it is floated off the needle on its own royal jelly or onto a previously primed jelly bed. Once each cell bar is completed it is placed upright in the holding frame and covered with a damp cloth. When the holding frame is completed it is carried upright to the cell builder and turned very carefully just before placing between a frame of pollen and a frame of brood. If the grafting is slow, then as each bar is completed it should be placed in the cell builder, to prevent chilling and drying of the larvae.

Developing queens are susceptible to injury through careless handling. Holding frames must never be shaken to remove bees; rather, bees should be gently brushed off with a soft bee brush or a handful of long grass. Shaking and jarring may dislodge larvae from their bed of royal jelly and may damage the developing pupae.

When queen cells are ripe (figure 47) they may be removed from the cell builder and either incubated overnight or taken directly to mating nuclei or dequeened colonies. Care must be taken that the cells are not chilled or overheated; a small cooler containing a hot water bottle and a sponge or styrofoam block with holes to hold the queen cells may be used for transport. Cells must be kept in their proper orientation with the capped tip pointed downwards, or the developing queen may be dislodged and injured.

Figure 47.
Mature (ripe) queen cells, on cell bar frame, ready for use in mating colonies or in colonies to be requeened.
(Photo P. Laflamme).

Queen mating colonies — Mating colonies range from miniature nuclei to full sized colonies requiring a new queen. Nuclei can be made up of standard depth supers divided into two bee-tight sections, each holding four frames, with individual entrances facing in opposite directions, covered with sacking so that each nucleus can be worked separately. Each nucleus contains a frame of honey, a frame of brood, and two relatively empty frames, all with accompanying bees. Nuclei may be moved to a separate yard to prevent drifting back to parent colonies; if left in the original yard they should be moved away from the parent colonies and reoriented. Mating nuclei must be arranged in such a manner as to aid the queens in orientation, with plenty of landmarks and entrances facing in different directions.

XII. HONEY BEE HEALTH

There are numerous diseases, predators and conditions which affect the health and vigor of the honey bee colony. The beekeeper must know the appearance of healthy bees and brood (figures 48 and 49) so that deviations from the norm will be recognized. Acquaintance with the symptoms of the common diseases will be worth while in diagnosis and treatment. A quick check for abnormal brood and adult appearance and for signs of unwelcome predation is a part of regular colony maintenance.

HONEY BEE BROOD DISEASES

American foulbrood — American foulbrood (AFB), caused by the bacterium *Bacillus larvae* (White), is probably the most serious and certainly the most studied of all the honey bee brood diseases. If unchecked it can spread in and amongst colonies, causing severe weakening and colony death. Spores of the bacterium remain viable for many years and are capable of causing fresh outbreaks whenever conditions are favorable. The provincial Bee Acts were first written mainly in an effort to control the spread of AFB, and disease inspection programs continue to the present day.

Figure 48.
Healthy frame of brood. A band of pollen is present between the honey and uniformly capped cells.

Life Cycle and Spread of AFB — Infection begins when the young larva ingests AFB spores along with its brood food. Larvae appear to be most susceptible when less than three days old; as they grow older they become resistant to infection. Spores germinate and the vegetative forms reproduce in the larval gut, migrating into the tissues of the larva and continuing to multiply there while feeding on the tissues. The bee dies in the prepupal or early pupal stage, after the cell has been capped. Death is due to toxins released by the bacteria, which begin to form more spores once the larval tissues have been utilized. The remains of one dead larva hold an estimated 2.5 billion spores.

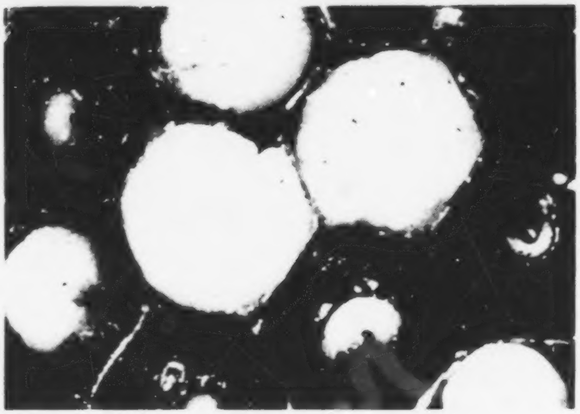


Figure 49.
Healthy larvae in various stages. (Photo, M. V. Smith).

The dead larva is eventually uncapped by house bees who attempt to clean out the cell and, in doing so, become contaminated with spores, which are then passed from bee to bee and eventually to more larvae. The adults themselves are not affected by AFB.

American foulbrood is spread amongst colonies by robbing and drifting bees. Often a colony weakened through disease cannot defend itself and is completely cleaned out by robbing bees, which may then carry AFB spores back to their own colonies. The disease may also be spread by exchange of equipment among colonies when equalizing colony strength or making up brood chambers, and when buying and selling infected equipment. Pollen and honey may carry AFB spores and therefore should only be fed back when from disease-free colonies. Package bees from infected colonies can carry enough AFB spores to cause fresh breakdown in hitherto disease-free equipment.

Symptoms — As the larval tissues break down they turn a uniform coffee color and lose all resemblance to a larva, eventually forming a gooey mass (figure 50).

Since the larva dies after capping, the decaying mass is stretched out in the bottom of the cell rather than coiled up in the position of a younger larva. At one

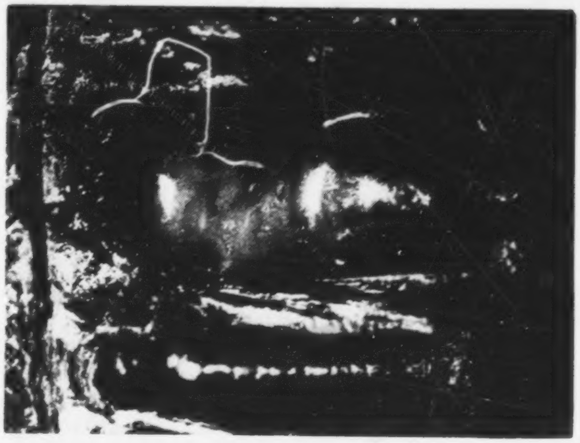


Figure 50.
Larva dead from American foulbrood after being capped over, cross sectional view. (Photo M. V. Smith).

stage the dead larva will exhibit some ropiness if drawn out with a toothpick or stick (figure 51). If the remains are not removed they dry into a flat brown or black scale, tightly adhering to the bottom of the cell (figure 52). This scale is the stage containing the dormant spores. Occasionally the pupal tongue remains upright.

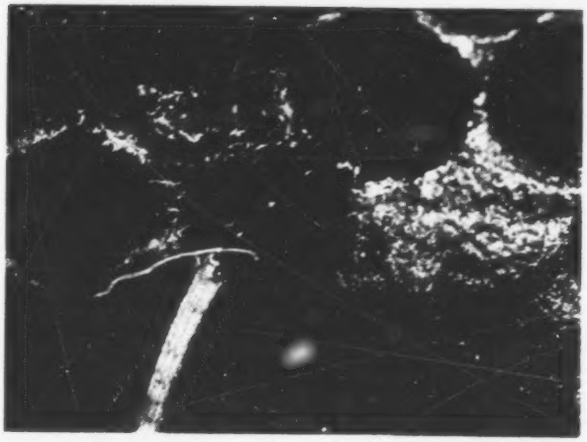


Figure 51.
Ropiness, characteristic of American foulbrood disease. (Photo M. V. Smith).

Also characteristic is a spotty brood pattern and the presence of dark brown, sunken and punctured cappings (figure 53), due both to the uncapping of dead larvae by the house bees and to the queen's reluctance to lay in cells containing scale. A distinctive odor may be present.

Diagnosis, Prevention and Treatment of AFB — A positive diagnosis is made by examining dead larvae and scale under a microscope for the presence of AFB spores. Samples for examination may be sent to the apiculture office. Samples of dead larvae or scale may be sent in wax paper in an envelope, or a small piece of comb may be cut from the suspect frame and sent in a box or other container.

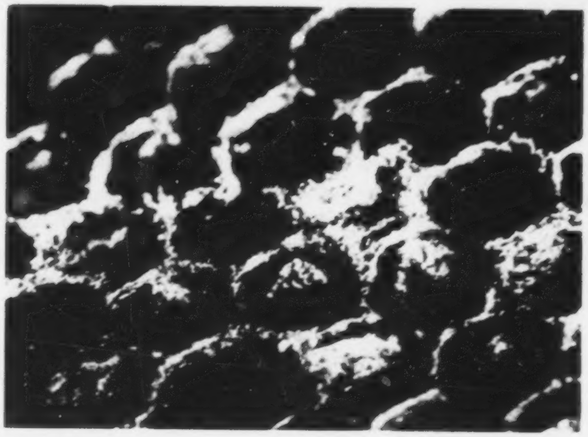


Figure 52.
American foulbrood scale on floor of cells.

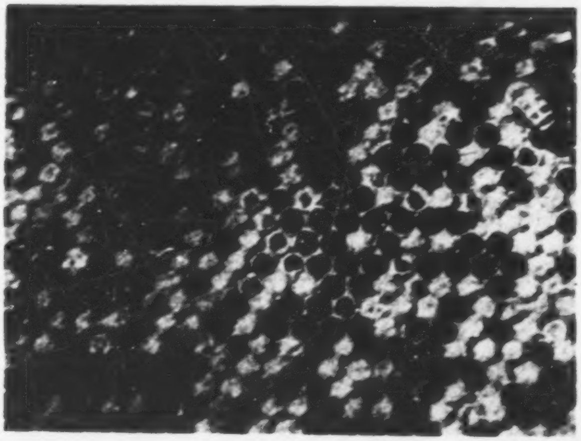


Figure 53.
Spotty brood pattern with punctured cells indicating American foulbrood.

The first step in American foulbrood control is to prevent its establishment in colonies, through the purchase and use of disease-free equipment, storage of equipment in bee-tight buildings, and management techniques which minimize robbing and drifting. The antibiotic oxytetracycline is useful both in preventing colony breakdown with AFB disease and in treating infected colonies after visible signs of the disease have been removed. If the beekeeper is located in an area heavily populated with honey bees he or she may feed oxytetracycline to the colonies as a preventative measure. Should AFB spores then be brought into the colonies the disease does not establish itself, as long as the effects of the antibiotic are present. Along with regular spring and fall feeding of oxytetracycline, the beekeeper should be constantly on the lookout for abnormal brood pattern and appearance during colony checks. Whenever combs are to be exchanged among colonies they are first checked, and when brood chambers are made up each comb is carefully examined for evidence of scale or fresh breakdown.

When looking for scale the frame should be held with the bottom bar pointing away, at such an angle that the bottom side of the cell is clearly visible. Good light is essential, especially when inspecting dark combs. Sunlight or a 200 or 300 watt light bulb is advisable.

Diseased colonies require both immediate and long-term treatment. If the diseased colony is strong, frames containing infected brood should be removed and burnt and the colony then treated with oxytetracycline. A colony which is weakened from a severe case of AFB should be killed and the dead bees and combs burned. Infected brood combs may be melted down but must never be exposed to bees in the meantime.

Infected equipment should be run separately for at least two disease-free years. The quarantine yard is treated with oxytetracycline and closely observed. Frames containing honey and pollen are constantly rotated so that the stores are used up, allowing the bees to clean out each comb while being fed oxytetracycline. Any combs showing fresh breakdown are culled and burned or melted down. American foulbrood disease can be controlled and effectively eradicated over several years, provided the beekeeper maintains a constant vigilance, inspects regularly, and does not hesitate to cull combs and take other positive action against the disease.

European Foulbrood — European foulbrood (EFB) is a brood disease associated with a complex of bacterial organisms. The bacterium *Streptococcus pluton* White is the main causative organism, while secondary bacteria such as *Bacillus alvei* enter and feed on the tissues of the dead larva. EFB is not generally considered a serious brood disease although under certain conditions it can be quite severe.

Life Cycle and Effects of EFB — Larvae which are less than 48 hours old when infected are killed by EFB, but older larvae may be weakened and stunted by the disease. The bacterium is ingested with the brood food and multiples in the larval gut, occupying the space between the food and the gut lining and competing with the larva for food. Within five days the larval midgut is full of bacteria, which effectively starve the larva. Nurse bees will eject some of these larvae which have an abnormally high demand for food.

Larvae infected with EFB generally die in the curled stage before capping occurs, although death occasionally occurs after capping as well. While cleaning out the cells house bees become contaminated with *S. pluton* and pass it on to other adults and larvae. If the larval remains are not removed they will dry into a scale, in which *S. pluton* will overwinter in a dormant state. Overwintering may also occur in feces and debris. The disease can spread from colony to colony through robbing and drifting, exchange of hive equipment, feeding pollen from diseased colonies, and installation of infected packages.

European foulbrood appears in colonies primarily in spring and early summer; the onset usually coincides with the first nectar flow. If severe, the disease may prevent colonies from reaching full strength in time for the main nectar flow. Generally, though, symptoms disappear as the season progresses, and it seems that strong colonies overcome the disease. Stresses such as that of brood nest expansion, uncertain spring weather, and moving colonies for pollination purposes may be factors involved in the appearance of EFB.

Symptoms of EFB — Because death usually occurs prior to capping, dead larvae appear curled and contorted (figures 54 and 55). The larval color changes from pearly white to yellow and brown, and the tracheae or breathing tubes stand out around each segment and along the sides as silvery lines (figure 44). Larval scale retains the curled shape and is easily removed from the comb, which may be one of the reasons that colonies can overcome slight infections.

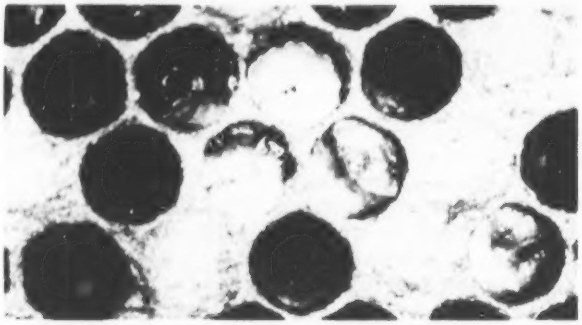


Figure 54.
Larvae killed by European foulbrood prior to capping over. The silvery tracheae can be seen in the larva at the top left. The centre larva is healthy. (Photo M. V. Smith).

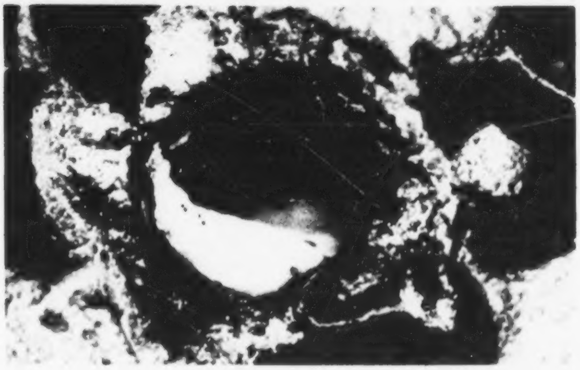


Figure 55.
Close-up of European foulbrood killed larva. (Photos M. V. Smith).

A spotty brood pattern and a sour odor may be present. Some death does occur in the stretched-out stage (figure 56), and these larvae may resemble larvae killed by AFB, so care must be taken to try and distinguish the two diseases by searching for more definitive symptoms.

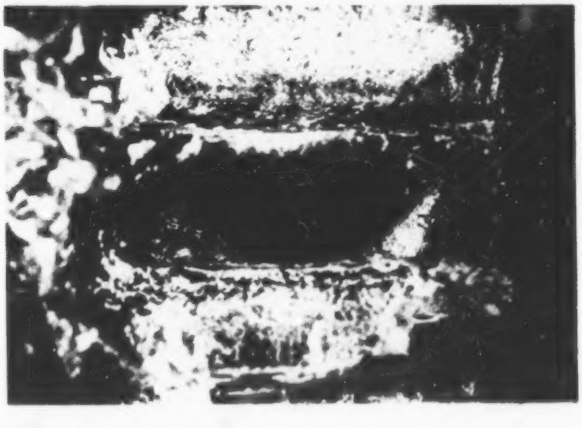


Figure 56.
Larva killed by European foulbrood in the prepupal stage after capping. This may be confused with American foulbrood. (Photo, M. V. Smith).

Prevention and Treatment of EFB — As with American foulbrood, a positive diagnosis for European foulbrood can be made by examining larval remains under the microscope. Although *S. pluton* is not a spore-forming bacterium, the close association of *Bacillus alvei* with the disease makes the presence of *B. alvei* spores a clear indicator. Samples may be sent for diagnosis to the apiculture office.

Management to ensure strong, healthy colonies will help in preventing European foulbrood outbreaks. Light infections often clear up as the season progresses, but heavily infected colonies should be isolated and equipment quarantined and kept separate. Frames containing more than a few infected larvae may be removed and destroyed. Since oxytetracycline is effective against European as well as American foulbrood, diseased colonies are treated with oxytetracycline and are marked for further inspection and treatment (see the appendix, Recommendations For Feeding Antibiotics).

Chalkbrood — Since 1971 chalkbrood disease has been steadily increasing in both incidence and severity. In 1971 it was identified for the first time in Canada, yet in 1975 and 1976, 32 per cent and 29 per cent of surveyed hives across western Canada exhibited some level of chalkbrood.

Chalkbrood is caused by a fungus, *Ascosphaera apis* Maasen ex Claussen (Olive et Spiltoir), which has a + and a − (or female and male) form. Either form can infect and kill honey bee larvae, but both forms must be present for spores to be produced. The spore is the dormant resting stage. Spores are ingested by the larva, which is most susceptible to the disease at 3-4 days of age, and germinate in its digestive tract. Growth of the vegetative form, the mycelium, occurs out of the hind end of the gut once the larva has been capped over. The dead prepupa looks white and fluffy at first but quickly dries down to a hard, shrunken, chalklike "mummy", white in color, or gray to black as spores are formed on its surface (figure 57). The worker bees eventually uncap and remove these mummies (figure 58), and they can be found on the bottom board and around the hive entrance. If a comb containing chalkbrood mummies is shaken the rattling of the mummies in their cells can be heard. Spores, viable for up to 15 years, may remain in hive equipment and

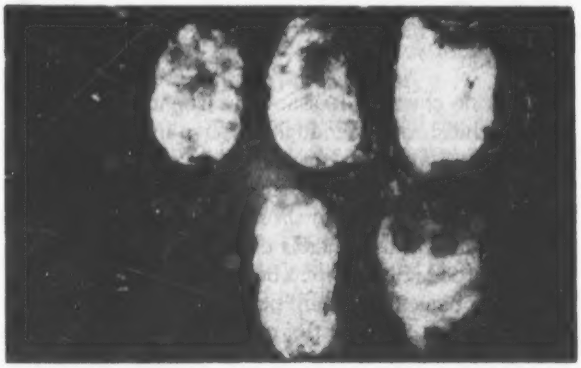


Figure 57.
Chalkbrood killed larvae showing both white and grey "mummies".

may overwinter in the ventriculus of adult honey bees, being passed on to larvae and regerminating when conditions are favorable. Generally the highest infection levels are found in mid-June.

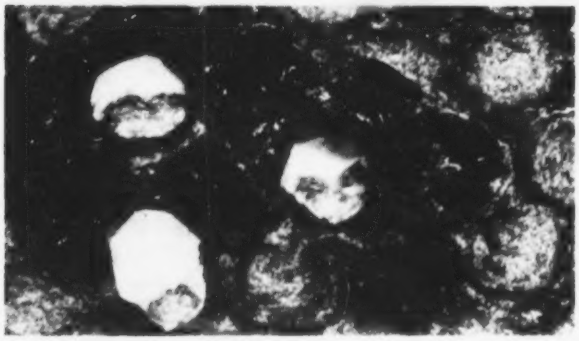


Figure 58.
Chalkbrood mummies exposed in the comb after uncapping.

Chalkbrood is a disease which commonly appears when the colony is under stress from other factors. A high level of spores may be present with no symptoms of the disease occurring in a strong and otherwise healthy colony, whereas a colony weakened by other disease or stressed through early spring brood-rearing, long periods of confinement, poor ventilation, lack of food or poor management may break down. Incidence of chalkbrood varies from year to year and from region to region. In most cases the colony shows only a few chalkbrood mummies in the late spring and the symptoms disappear in the summer. However, the beekeeper may notice some colonies where many mummies are evident in combs, on the bottom board and in front of the hive, with a corresponding decrease in amount of capped brood. Thus, while chalkbrood has not been considered a serious threat to beekeeping, it can cause loss of a fair amount of brood, which must reflect eventually on honey production.

There is no chemical registered in Canada for use against chalkbrood, although research in Canada and the United States has indicated some potential compounds. As with other stress-related diseases proper management and strong healthy honey bee colonies are the best means of prevention and control of chalkbrood. Spores may be spread via adult and immature bees, the queen, pollen and equipment from infected hives. Shipment of queens and package bees throughout the United States and Canada has been suggested as one explanation for the wide and rapid spread of the disease. Pollen for feeding back to bees should not be trapped from colonies with chalkbrood or any other disease. Old brood combs with a high number of mummies may be destroyed, and sheltered apiary sites with good air drainage should be used. Poor ventilation and moisture accumulation may be avoided by the addition of an upper entrance to wintering colonies. Severely affected colonies may be killed or requeened, as some genetic susceptibility may exist.

Sacbrood — Sacbrood is a viral disease of the brood which can be grouped with chalkbrood and European foulbrood as appearing in colonies especially in the spring and early summer buildup period.

Symptoms include uncapped or partly uncapped dead larvae/prepupae scattered throughout the brood area and capped cells in areas where brood has emerged. The initial reaction to this brood comb appearance may be that this is a case of foulbrood. A closer examination of dead individuals will reveal that they are not sunken into the bottom of the cell, but instead appear bloated (figure 59). If carefully removed from the cell a sacbrood larva retains its shape (figure 60); the skin is hardened and leathery and appears to be fluid-filled. The head darkens to a dark brown, followed by darkening of the rest of the body. There is no gooeyness or ropiness, in contrast to foulbroods.

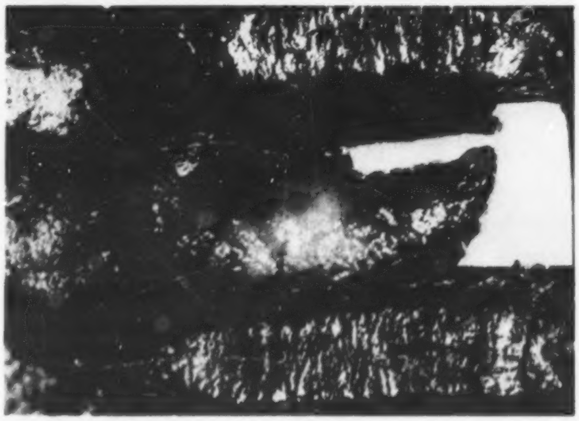


Figure 59.
Cross-section showing a sacbrood killed larva. Note the bloated appearance and darkened head, characteristic of the disease. (Photo, M.V. Smith).

Viral diseases are diffcult to treat in most organisms and sacbrood is no exception. As with all honey bee disease, management techniques which minimize stress will help. It may also help to cage the queen for up to a week to break the brood cycle, allowing housekeeping bees to clean out all dead brood without new susceptible brood being present. Sacbrood virus is

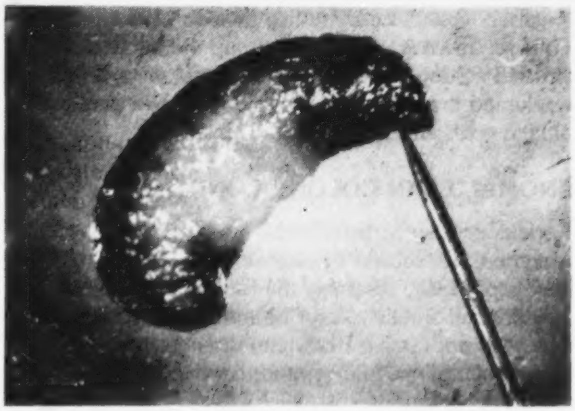


Figure 60.
Fluid-filled sacbrood larva upon removal from the cell. Larvae are removed easily unlike American foulbrood. (Photo, M.V. Smith).

apparently infective for only a short time; breaking the brood cycle may therefore also break the disease cycle. Heavily-infected colonies may be requeened with less susceptible stock. While sacbrood disease is not considered too serious, occasional severe outbreaks have been reported.

Sacbrood virus has been isolated from dead pupae indicating that the virus may cause death at later stages under certain circumstances.

ADULT HONEY BEE DISEASES

Nosema disease — Nosema disease is caused by a single-celled protozoan animal. *Nosema apis* Zander. Because nosema affects adult honey bees it is not as easily detected as some of the brood diseases which exhibit decaying larvae, ropiness, foul odors and other notable symptoms. Often the beekeeper is unaware that colonies are suffering from nosema until the disease is well-established and the damage done. Yet nosema has been given the dubious honour by some authors of being more economically damaging than all the other bee diseases common in North America put together. Nosema disease affects every segment of the beekeeping industry, from queen and package producers to crop pollinators and honey producers.

Life cycle and effects of nosema — The dormant stage of *Nosema apis* is a spore which is long-lived and resistant to dehydration and temperature extremes. Spores are ingested by the adult bee and pass through the honey stomach to the ventriculus or true stomach. There they germinate and enter the cells of the gut lining, where they multiply and eventually fill each cell with new spores. These cells are then shed into the ventriculus and burst, releasing the spores to invade new cells and to pass out of the bee in its feces. Should defecation occur within the hive, the reservoir is formed for infection of house-cleaning bees engaged in late winter preparation of the brood nest. Once good flight weather prevails infected bees will defecate or die away from the hive, thereby lessening the chances of infecting other bees.

Honey bee colonies are most susceptible to nosema buildup when the population is small or made up of old bees, and when replacement is slow, in the early spring in wintered colonies and in the first month after hiving packages. Incidence of the disease varies through the year, with a major peak in the spring and a minor peak in the fall.

Nosema impairs digestive processes and causes premature aging and death in worker bees. Essentially, infected bees starve to death because they cannot digest any food. Nosema causes the hypopharyngeal glands, which produce protein-rich royal jelly, to atrophy; thus brood-rearing is curtailed. Severely infected bees look swollen and act as though in a stupor, crawling about in the hive or in front of the hive with wings unhooked. Nosema can be found in drones and the queen and will cause degeneration of the queen's ovaries, resulting in supersedure or queenlessness. Nosema is probably the major cause of queen supersedure in package colonies.

These effects on the queen and on the workers will lead to dwindling of the adult population, curtailed brood-rearing, and queen problems, all of which lead to reduced honey yields.

Diagnosis, Prevention and Treatment of Nosema — The only positive diagnosis of nosema disease is to examine the contents of the bee's digestive tract for the presence of spores. Examination may be done by the beekeeper, if a compound microscope is available, or a sample of bees may be sent to the apiculture office (see below for the sampling procedure).

A combination of good management and the regular use of fumagillin will keep nosema incidence to a minimum. The best natural defense is a strong healthy colony, with a prolific queen and plenty of young bees to replace any dying bees. Food stores must be adequate at all times. Apiary sites should be sheltered from wind and have good air drainage.

The antibiotic fumagillin is effective against *Nosema apis* in both package and wintered colonies.

Nosema may be present in packages shaken from infected colonies. Package producers may feed fumagillin to their colonies and mating nuclei and put fumagillin into the syrup given to packages en route as a matter of course. If this is not the case the beekeeper may supply the fumagillin and request that it be added to the syrup for his or her packages. In order to further ensure against a nosema outbreak and queen problems, fumagillin should also be fed in syrup to newly-hived packages.

Control of nosema disease in the overwintering operation will take a minimum of two years of feeding medicated syrup in the fall to repress spring outbreaks. With fumagillin, spore levels will drop down each spring until the disease level is not economically damaging. Further feeding of fumagillin each fall will keep nosema in check. The best time to sample overwintered colonies for the presence of nosema spores is in the April-June period. At this time nosema spore levels will be at their highest. Sampling may also be done in the early fall. To control the disease, the colonies should be given fumagillin in the fall feed. The medicated syrup will be stored in the combs and will retain its antibiotic activity through the winter, repressing the buildup of spores and preventing a spring outbreak of nosema disease.

Sampling for nosema — Every colony may be sampled if the beekeeper owns only a few colonies. Otherwise every second or third colony in a yard is sampled by blocking the entrance for a few moments and picking off about ten bees, pinching their thoraxes and placing them in a container or placing them directly in alcohol (rubbing alcohol or ethanol). It is not necessary to keep bees from each colony separate. Field bees are taken rather than house bees. Samples are sent in cardboard containers or in alcohol to the apiculture office immediately upon collection. Plastic bags, prescription bottles and so on should not be used as they allow the development of other organisms which break down bee tissues and obscure the presence of nosema spores. Results of the diagnosis can be used to predict the necessity of fall feeding of fumagillin in to that yard only or to the whole operation.

Bee paralysis — Symptoms of bee paralysis are very occasionally noted by beekeepers, generally in a single colony in an apiary. Adult worker bees appear hairless, greasy or shiny and black, with disjointed wings and distended abdomens. They are unable to fly, seem to have some paralyzed legs, and exhibit crawling and trembling behavior. Healthy bees attempt to remove the crawlers from the hive and there may be large numbers of dead and dying bees around the hive entrance.

This disease is caused by a virus, and there is variability in genetic resistance by honey bees to virus infections. Thus requeening will likely clear up the disease in the affected colony. Alternatively, if the colony is terribly weakened the bees may be destroyed. Bee paralysis is of little economic importance in Canada.

ANOMALIES IN COLONY CONDITION

Conditions may be seen in the honey bee colony which are not caused by disease organisms but which may superficially resemble the foulbroods. Close examination should always be made of brood or adults which do not appear healthy to distinguish between disease symptoms and symptoms of any of the following conditions.

Chilled brood — In early spring when the brood nest is rapidly expanding, a cold period may cause the bees to cluster and leave brood in peripheral combs unprotected. Prolonged exposure to temperatures below 14°C will cause death, with young brood more temperature-sensitive than capped brood. Similarly, cold weather following a reduction in adult bee numbers will cause chilled brood, for example, when divisions have been made (see section 5) and many of the adults have left the division and returned to the parent hive. Chilled larvae are removed by adult bees but chilled and dead capped brood may be left for several weeks. Chilled brood is darkened, granular or watery, never ropy. Its appearance, along with its location on outer frames and along the bottom edges of the brood combs will confirm that death was through chilling and not caused by a disease organism.

Gassed brood — When package colonies are gassed off in the fall the uncapped brood may be killed either by cyanide or by subsequent chilling or starving. Capped brood is somewhat protected from cyanide fumes and often hatches out even after the adults have been killed. Dead brood becomes darkened and degenerated, and may look as though it died of disease. When there is doubt, samples may be taken for examination to the apiculture office.

Starvation — Starvation is especially common in the spring buildup period. Both adults and brood will suffer if there is not enough food in the hive. Lack of food or a reduction in adult numbers will cause house bees to remove brood from the combs and eat it or drop it in front of the hive entrance. A pollen shortage may be recognized (too late) by the presence of dead pupae in front of the hive. Severe food shortage will cause starvation in the adult population. Slow-moving and trembling bees, along with empty honey frames, signify that the colony is on the verge of death. Once the bees show these symptoms they take a long time to recover.

Dying bees crawl head-first into cells where they remain after death. Warm 2:1 sugar syrup should be sprayed over the bees and in empty combs next to the cluster to revive starving bees.

Starvation can easily be prevented, firstly by supplying adequate food stores before going into winter, and secondly by supplying more food in the spring or whenever necessary. Early spring checks must be made to determine when feeding will be necessary. The colony should have at least 14-18 kg honey (five or six honey frames) at all times. A lack of capped honey at any time, especially during the brood-rearing period, means that the colony must be fed immediately. As little as 12 hours is all it takes to starve the adult population.

Dysentery — Normally, honey bee adults void their feces when in flight and do not defecate when confined to the hive. If they are confined over a long period and are feeding on poor quality food stores, the accumulation of large amounts of undigestible matter and water in the rectum will cause defecation in the hive. Symptoms include spattered entrances and frames. Dysentery may be a factor in premature death of adult bees, thus weakening the colony. Poor quality food should be avoided for winter stores, including frames of high moisture or granulating honey, burnt honey, honeydew, or syrup made from other than refined sugar (see section 4).

MITES

Mites are not insects but are in the phylum Arthropoda along with insects, crustaceans, millipedes and centipedes. They are closely related to spiders, ticks, scorpions and pseudoscorpions, all of which have eight legs. There are four species of mite which are parasitic on honey bees as well as several species which live externally on honey bees but which apparently do no harm. Two of these mites are found in North and/or South America. There is a real possibility that these two species may be introduced into our beekeeping industry through movement of infested bees into the package-producing states and subsequent importation in packages or through the illegal importation of honey bees into Canada. It must be emphasized that importation of adult or immature honey bees of any caste from anywhere except the United States and New Zealand (for which a permit is required) is illegal, for the good reason that diseases may be brought in which are not already present in Canada.

Varroa disease — The mite *Varroa jacobsoni* Oudemans is a honey bee parasite native to southeast Asia, which has been widely distributed throughout the world as a result of unrestricted movement of honey bees by humans. It is present in several European, Asian, and South American countries. This mite is a parasite affecting both brood and adult honey bees. Female mites lay eggs in the cells of late instar larvae, preferring drone larvae but parasitizing workers as well. The mite nymphs feed on the haemolymph (blood) of the larvae and pupae by piercing their body walls (figure 61). Damage and loss of haemolymph causes weight loss and may cause the death of the immature bees, or the bees may hatch out abnormally small and with deformed wings. Adult mites attach themselves to adult honey bees and often crawl between the overlapping abdominal plates (figure 62), where they are difficult to see and impossible to dislodge. There they feed on adult haemolymph, causing weakening and some mortality.

Figure 61.
Varroa jacobsoni feeding on developing pupa.
(Photo Akratanakul).

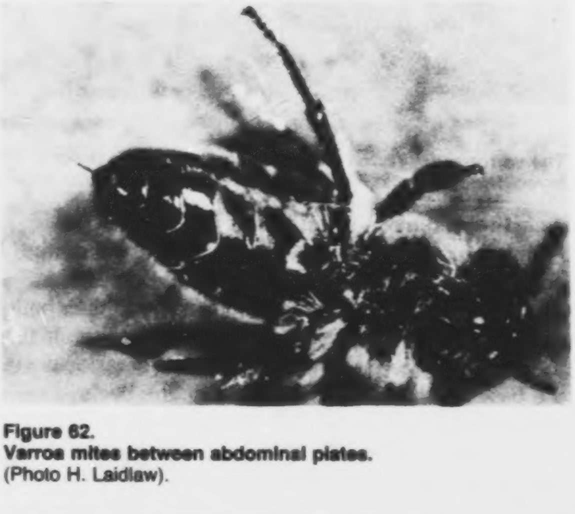


Figure 62.
Varroa mites between abdominal plates.
(Photo H. Laidlaw).

The overall effect of a heavy varroa infestation is the dwindling, weakening and eventual death of honey bee colonies. Symptoms are not easily noticeable in the early stages; after some time the beekeeper notices poor buildup and general weakened condition of the colony. By this time the mites have likely spread in and amongst apiaries. To see the mites, adult bees must be examined and brood must be uncapped and removed from cells.

Alternately, colonies may be sampled by placing stiff white paper on the bottom board and examining the collected debris after treating the colony with tobacco smoke or a fumigant. Adult varroa mites bear a superficial resemblance to the bee louse (*Braula coeca*) (see below and figure 63).

Treatment for varroa infestation is not standardized, and while several fumigants are advertised in European countries as effective, none appears to be outstanding. Fumigation of individual colonies would be at best tedious and time and labor intensive. Varroa cannot live for many days away from live bees, so killing of colonies and cold storage of equipment may be effective, providing that a varroa free source of package bees is available.

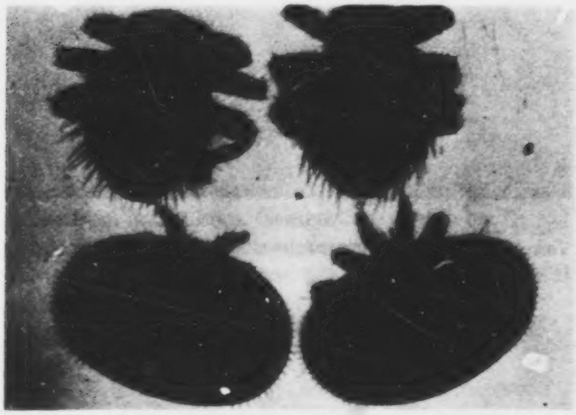


Figure 63.
The varroa mite, Varroa jacobsoni compared with the bee louse, Braula coeca (Photo H. Laidlaw).

Acarine disease — The honey bee tracheal mite, *Acarapis woodi* (Rennie), spends its entire life on the adult honey bee. Adult female mites are transferred from one host bee to another by clinging to their hair; once on another young bee, they move into the main thoracic tracheae or breathing tubes, or occasionally to the bases of the wings. They feed on the bee's haemolymph by piercing the tracheae with their mouthparts. Within a short time after infesting a new host, eggs and young mites are present; growth and mating take place within the tracheae and new adult females leave to find another host. The mites cause some damage to tracheae, flight muscles and nerves, and likely affect oxygen uptake by the bee, thereby shortening the bee's life span. Acarine disease appears to cause weakening and dwindling of colonies especially in winter, probably contributing to winter losses.

A positive diagnosis can be obtained only by examining the prothoracic tracheae under a microscope for presence of mites. As with varroa disease, tracheal mite infestation is treated with fumigants which kill mites but not honey bees. If populous colonies are maintained acarine mites may not be as much of a problem as in weak colonies.

Other parasitic mites — Two other mites, *Tropilaelaps clareae* Delfinado and Baker and *Euvarroa sinhai* Delfinado and Baker, are found on *Apis* species in tropical Asia but as yet have not been reported from northern Asian, European, or American countries.

External mites — There are three named species of *Acarapis* which live externally on adult honey bees. These mites, *Acarapis externus* Morgenthaler, A. *dorsalis* Morgenthaler, and A. *vagans* Schneider, are widespread in distribution, and are probably present wherever honey bees are kept. They appear to cause no harm to honey bees.

INSECT PESTS OF HONEY BEE COLONIES

Ants — Ants are a major pest of honey bee colonies in tropical and warm temperate climates, and may occasionally be a severe problem in colonies in Canada. If ants enter hives in search of food they are difficult pests for the guard bees to catch and remove. A continual stream of ants entering the hive will anger the bees and put the colony on the defensive, and may decimate the colony population. Species such as carpenter ants may cause structural damage to hive parts, especially bottom boards. Some ant species tend to start nests in the warm, protected space between inner and outer covers; these ants do not generally bother the bees below but constitute a nuisance to the beekeeper.

If ant nests are found in the apiary they may be destroyed with gasoline, diesel oil, or insecticide. Diazinon as a 2 per cent dust may be used under the backs of hives. Care must be taken that the chemical does not contact the bees or brood. Chlorpyrifos granules also kill ants. Bottom boards must be solid so that the bees are not exposed to the pesticide, and hives should be up off the ground. Commercial and bait traps are available which can be placed under the appropriate hives or along ant trails.

Wasps — Wasps hovering around hive entrances and exposed supers are often noticed by the beekeeper. Bees usually manage to overcome the occasional intruding wasp quite effectively, and wasp predation on honey bees is not a threat to honey production under our conditions.

Wax moths — There are two species of moth which specifically feed on pollen, honey and hive debris. These wax moths can be a problem in stored hive equipment and occasionally in weak colonies. The female moth enters the hive or storage shed and lays eggs in cracks between frame and comb or in such spots, preferring dark combs to light. The larvae or wax worms tunnel through combs, consuming pollen, honey and debris, disturbing and damaging the honey bee brood, and breaking up the structure and integrity of the combs. Wax moth larvae are extremely destructive, destroying many combs in a short time.

Generally wax moths are not a problem in areas where hive equipment is stored over winter at sub zero temperatures. If hive equipment is stored through the summer, or in a heated shed in the winter, it seems to be only a matter of time until wax moths find it. As a precautionary measure such equipment should be stored in "moth-tight" stacks with lids, with cracks between supers taped up, if necessary, and paradichlorobenzene crystals or mothballs sprinkled on paper between each super to repel the moths. If moths are found in stored equipment all debris and webbed comb, which harbor the different life stages, should be destroyed. This can be accomplished by exposing the hive equipment to cold temperatues. The use of vapona for wax moth control is not recommended.

Wax moths may ruin comb honey both on the hive and in storage. It should be removed from the hive when capped and should be stored at cold or freezing temperatures for wax moth control.

Several other species of moth which feed on stored products such as grain and dried fruit moths are also occasional pests in stored bee hive equipment. It is likely, however, that the above control recommendations will be effective against these species as well.

The pesticide Certan, developed for wax moth control in the United States, appears to be effective against wax moth larvae while apparently harmless to honey bees. Certan contains the spores of a bacterium, *Bacillus thuringiensis* Berliner, which affect wax moth larvae in much the same manner as *B. larvae* (AFB) affect honey bee larvae. It appears to provide protection against wax moth infestation in stored hive equipment for up to twelve months, acting to kill existing larvae and any re-infestations over that period. Each comb must be sprayed with or dipped in the pesticide solution for protection. Beekeepers wishing to store hive equipment over a summer season may consider using this product as a safeguard.

The bee louse — The bee louse, *Braula coeca*, is not a true louse but a wingless fly which is adapted to clinging to the branched hairs of the adult honey bee. The adult louse feeds on pollen and nectar at the bee's mouth. Eggs are laid on the cappings of honey cells and the larvae tunnel through the cappings as they feed. The bee louse is generally considered harmless to honey bee colonies, but may become a pest if in high numbers by detracting from the appearance of the cappings of comb honey. The adult louse bears a superficial resemblance to the varroa mite (figure 63).

UNWELCOME INTRUDERS

Mice — Mice tend to find their way into overwintering colonies and stored hive equipment. If entrances are not blocked or screened mice will enter hives in the fall and will nest in the bottom brood chamber, chewing holes through brood frames in the process of nest-building. Mice also tunnel through the insulation surrounding wintering colonies, often rendering it unusable for the next year. In stored equipment mice will destroy combs by building nests and chewing on the wax for pollen and dead brood.

Overwintering hive entrances should be blocked down to a small size when winter wraps are put on. Some beekeepers block the lower entrance completely; others leave a small entrance (8 mm^2) in the centre, too small for mice to enter. Upper entrances are generally safe from mouse entry owing to their location and small size. Poisoned grain or commerical rodent bait may be placed on inner covers (feeder holes blocked) below the insulation and under hives.

If the storage shed is not rodent proof the stacks should be, with cracks blocked up and queen excluders or tight-fitting lids above and below each stack. If used in the shed, rodent bait or grain should be in flattened tin cans with small openings, so that other animals do not come in contact with it.

Skunks — Skunks can be a major problem in apiaries, especially in the spring and fall. Nocturnal by nature, skunks will scratch at hive entrances until bees fly out, then will lap up the bees caught in their fur. Stings do not seem to bother them. They will switch from hive to hive in an apiary, decimating the adult honey bee population in each hive and angering the colony to the point that it cannot be handled. Skunks also tear and damage winter wrapping material and may even nest in the insulation on top of the hives. Signs of skunk visitation include scratches on hive fronts, matted and torn vegetation, scratches or holes in the ground in front of the entrances, and extemely angry and weakened colonies.

Some beekeepers control skunk problems by baiting eggs with a small amount of strychnine and placing them under several hives in the apiary. While very effective against skunks, poisoned eggs are also effective against non-target animals and birds. Strychnine is not registered for use against skunks, thus this control method is illegal.

As skunks tend to stay in the vicinity and return to the apiary, trapping or shooting are effective and legal means of control. A completely closed box trap is apparently better for keeping the skunk from releasing its scent and may also help to retain any odor. Trapped skunks may be gassed, shot or released elsewhere. Plans for such a trap are available from the apiculture office. The fish and wildlife division will set and monitor box traps or will loan traps to beekeepers for as long as required.

A piece of screening extending up and out from the hive entrance will protect the hive and the winter wrap from scratching by skunks; if the skunk tries to climb the screen its underbelly will be exposed to bee stings. A board with many sharp nails pointed upwards placed on the ground in front of the hive entrance also helps to deter skunks from scratching at the hive.

Bears — Beekeeping operations can suffer tremendously from bear visitation in bee yards. Not only do bears eat the bees and brood, they usually destroy and scatter hive equipment and can cause thousands of dollars worth of damage to apiaries. The extent of bear damage varies from year to year with such factors as the severity of the previous winter, the reproduction and survival rate of young bears, and the availability of territory and natural food sources. Bears have to learn that honey bee colonies are a food source, but once discovered, they tend to return to the apiary or to visit other apiaries.

Bear damage to apiaries can usually be avoided. Apiary locations in or near preferred bear areas, such as stream banks and bush, will have an increased chance of bear problems. Yards should be located away from these areas, and kept clean of broken frames, comb and other bait.

Using electric fences around apiaries is the most effective means of keeping bears out. Fences, whether permanent or portable, must be properly constructed and maintained to be effective, and must be in place and in operation before a bear problem develops, for once the bear has a taste for brood a fence may not stop further entry. Construction should consist of posts 1.25 m tall and 6-8 m apart, with at least three wires at heights of 25 cm, 50 cm, and 75 cm. Steel telephone wire or electroplastic wire is preferable to barbed wire for ease of handling. A gate wide enough for trucks to pass through should be included. A 12 volt battery, preferably of a type used in recreational vehicles, and a good quality fencer are necessary. Solar fencers are also available. These may be located within the fence if problems with two-legged intruders are anticipated. The fence may be baited with bacon rind or a punctured sardine can so that the first parts of the bear to contact the fence are its nose and tongue. Vegetation must be mowed or treated with herbicide in a 50 cm strip under the fence to avoid shorting out the fence.

Portable bear fences can be built using PVC piping. Fences of electroplastic netting are commercially available as well. More information on bear fences may be obtained from the apiculture office.

If bear damage continues, shooting or trapping and removal are the alternatives. The wildlife division has culvert traps and snares which they will set out and monitor on request. They are responsible for taking care of any trapped bears. Trapping and poisioning of bears by the beekeeper is illegal. At the time of writing beekeepers may shoot bears on private land without a license. To shoot bears on Crown land a valid license must be held, which allows the beekeeper to shoot a certain number of bears in season. Dates and numbers of bears allowed are subject to change and for up-to-date information the beekeeper should contact the wildlife division.

The provincial government offers a bear damage compensation program to registered beekeepers who have sustained losses in bee yards. Information on this program may be obtained from the apiculture office.

The Africanized honey bee — The Africanized honey bee is now present in South, Central and North America. This bee originates from stock of *Apis mellifera scutellata*, a tropical honey bee strain from Africa, which was introduced into Brazil in 1956. Since its introduction and escape from managed hives this strain has migrated in all directions, has largely displaced the previously introduced European strains, and has changed the scope of beekeeping in tropical and subtropical areas of the Americas.

The Africanized bee differs from European strains in several ways. It tends to nest in much smaller cavities, and exposed nesting sites are common. It has a high swarming rate, and absconding often occurs, whereas in European strains absconding is rare. Honey storage characteristics differ: tropical African and Africanized strains tend to store less honey than do European strains. Individual workers differ in size and in length of life. Africanized worker bees are smaller and have a shorter lifespan than European worker bees.

The best known trait of the Africanized bee is its well-developed defensive behavior. Tropical African and Africanized honey bees have a greater tendency to react to colony disturbance: large numbers of workers will take part in this colony defense, and will follow intruders further and attack for a longer period than will European strains. Deaths of animals and of humans have been attributed to these prolonged attacks.

It is felt by researchers that the Africanized honey bee will not be able to withstand winter conditions throughout most of the United States and Canada. However, the presence of this strain may be disruptive in queen and package-producing areas of the southern U.S. and California. Should stock with strong defensive and swarming tendencies be brought into Canada in packages, its presence here, even during the summer, may cause problems with public relations as well as with hired help and honey production.

PESTICIDE POISONING OF HONEY BEES

Honey bees, being insects, are very susceptible to the toxic effects of insecticides. Pesticides are a necessary and unavoidable aspect of today's agriculture, but death of honey bee colonies through pesticide poisoning is unnecessary and can usually be avoided. The onus is on the beekeeper to take an active role in protecting his or her colonies from pesticide effects.

Toxicity of pesticides to honey bees

Pesticides enter honey bees most commonly by direct contact, through contact with spray droplets in the air and with sprayed plant surfaces. Pesticides may also enter orally or through the respiratory system. Once inside, the pesticide may affect the digestive tract, so that the adult bee can no longer nourish itself, or the nervous system, so that legs, wings and organ systems no longer function properly. Death may be immediate, in which case bees die in the field, or delayed, so that they die in or near the hive. House bees and brood may also be affected if pesticides are carried back to the hive. Pesticides may also have sublethal effects on the colony, distrupting egg-laying and normal colony functioning, and causing chilling or starvation of brood.

Bee poisoning may occur when crops on which bees are foraging are sprayed. But poisoning may also occur indirectly, through drift of sprays to adjoining fields, or through contamination of flowering weeds such as dandelions and hawk's-beard in the field or orchard. Dichlorvos (Vapona no-pest strips) has a high affinity for wax, and will be absorbed into exposed beeswax combs, subsequently being released in lethal doses and killing both adult bees and brood. **Vapona strips should never be used in honey houses or sheds where combs are stored.**

The formulation of the pesticide is a major factor affecting both its immediate and residual toxicity to honey bees. Any formulation which increases the amount of pesticide contacted by honey bees will generally increase its toxicity. Thus dusts and sprays of wettable powders are often more toxic than sprays of liquid formulations such as emulsifiable concentrates; coarse sprays are more toxic than fine sprays; granular formulations are usually very low in toxicity because the toxic compound is not available for direct contact.

Incorrect dosage and application times may greatly increase toxicity and hazard to honey bees. Many pesticides are not harmful to honey bees if applied in the correct formulation, at the correct rate, and at the correct time of day. These pesticides may be highly toxic but have a short residual effect, breaking down to a safe level soon after application. Thus, if they are applied at dusk after the bees have stopped foraging, or in some cases in the early morning before foraging begins, by the time the bees reach the field there is no longer any toxic effect. Some pesticides and some formulations are extremely toxic to honey bees and must not be applied to flowering crops or weeds at all, while some are relatively non-toxic to honey bees and may be applied during flowering, but never while bees are foraging. Residual toxicity of a pesticide may also be affected by temperature.

Symptoms of bee poisoning — Symptoms vary depending on the type of pesticide used. Large numbers of dead bees in front of hives are typical, as is severe dwindling of the adult population. Dying bees may appear paralyzed, stupefied, unable to fly or walk without tumbling; nectar may be regurgitated, causing bees to look wet; the abdomen may be swollen; bees may be very aggressive. Abnormal brood patterns may

TABLE 10. Some pest problems potentially affecting honey bees through direct spraying of bees and/or colonies or through spray drift to flowers in adjacent fields and along roadsides.

insect	time of year (stage of crop)	plant species	recommended treatments (1986)*
forest tent caterpillar	May, June	shelterbelts and bush	Dipel, Thuricide[4] Dylox 420[3] Methoxychlor EC[3] Malathion 50 EC[2] Sevin XLR[2] Diazinon EC[1] Sevin WP[1]
flea beetles	late May - mid June (in seedling stage)	canola mustard	IN-FURROW AND SEED Lindane[4] Furadan 5 G[4] Counter 5 G[4] FOLIAR SPRAYS Decis 5.0 EC[2] Malathion 500 EC[2] Supracide 25 EC[1] Furadan 480 F[1] Sevin liq. susp.[1] Guthion 240 SC[1]
cutworms	late May - mid June (seedling) July (bloom)	canola, flax, sunflowers canola	Lorsban 4E[1] Lannate L[1]
sweet clover weevil	late May - mid June (seedling stage) Fall	sweet clover	Sevin XLR[2] Malathion 500 EC[2] Cygon 480 EC[1] Sys Tem 480 EC[1] Guthion 240 SC[1] Sevin liq. susp.[1]
lygus and alfalfa plant bugs	late June (pre bloom) late July (bloom)	alfalfa (seed)	Dylox 420 L[3] Decis 5.0 EC[2] Supracide 25 EC[1] Sys Tem 480 EC[1] Cygon 480 EC[1]
alfalfa weevil	mid-June (pre bloom) mid-summer (bloom)	alfalfa (seed)	Malathion 500 EC[2] Guthion 240 SC[1] Furadan 480 F[1]
alfalfa looper	late June, July (pre bloom, bloom)	alfalfa (seed)	Lorsban 4 E[1]
grasshoppers	all summer	all crops pastures	ALL CROPS Hopper Stopper[4] Sevin XLR[2] Malathion 500 EC[2] Furadan 480 F[1] OILSEEDS Monitor 480 L CEREALS Decis 5.0 EC[2]

insect	**time of year (stage of crop)**	**plant species**	**recommended treatments (1986)**
grasshoppers, cont.			Guthion 240 SC[1] Sevin liq. susp.[1] Cygon 480 EC[1] Sys Tem 480 EC[1] Hopper Spray 400 EC[1] FORAGES Guthion 240 SC[1] Cygon 480 EC[1] Sys Tem 480 EC[1] Supracide 25 EC[1]
wheat midge	late July, early August	wheat, barley	Furadan 480 F[1] Lorsban 4 E[1] Cygon 480 EC[1] Sys Tem 480 EC[1]
diamondback moth	late July, August (bloom, post bloom)	mustard canola	Dylox 420 EC[3] Malathion 500 EC[2] Guthion 240 SC[1] Supracide 25 EC[1]
bertha armyworm	mid-August (bloom, post bloom)	canola flax	Lorsban 4 E[1] Monitor 480 L[1] Lannate L[1]
aphids	August	forage crops	ALL CROPS Cygon 480 EC[1] Sys Tem 480 EC[1] CEREALS Systox 240 SC[3] FORAGES Systox 240 SC[3] Malathion 500 EC[2] Supracide 25 EC[1]
ants	beekeeping season in bee hives		diazinon 2% dust under back of hives (MUST NOT contact bees or comb)
flies, honey bees, wasps	July, August in honey house		bee-tight building bee escapes in windows flyswatters DO NOT USE VAPONA!
wax moths	year-round in stored supers		store at subzero temperatures Paradichlorobenzene crystals between supers. Bacillus thuringiensis (Certan)[4] DO NOT USE VAPONA!

* Recommendations from Chemical Control of Field Crop Insects (Alberta Agriculture Agdex 100/622) and Field Crop Insect Control (Saskatchewan Agriculture). Toxicity ratings from Carl Johansen, Entomologist, Washington State University, Pullman, Washington.

[1] Highly toxic to honey bees. Do not apply to crops or weeds in bloom.

[2] Apply only during late evening.

[3] Apply only during late evening, night or early morning.

[4] Can be applied at any time with reasonable safety to bees.

be seen or the queen may stop egg laying altogether, and house bees may begin supersedure cells. Chilled and dead brood may be seen in combs or in front of the hive. Colonies may be completely dead, or the population may be knocked back enough that honey production will be reduced.

Preventing losses — Most growers and spray applicators do not want to kill honey bees. But if a crop is threatened by a pest outbreak the grower is going to spray, bees or no bees. It is up to the beekeeper to protect colonies from being severely set back or destroyed.

Following are several considerations that, if applied, should allow for insecticide use with a minimum of risk to bees:
- Initiate and maintain contact with the farmers and commerical pesticide applicators in your area and let them known where your colonies are located.
- Clearly post your name, address and telephone number at each apiary location so that you can be easily contacted by local farmers and pesticide appliators.
- Become familiar with the common insect pests in your area and when spray programs take place so that you will be aware of the problems facing the grower and when the bees may be threatened (table 10).
- Pesticide applicators should be encouraged to use the pesticides that are least toxic to bees.
- Restricting the application of many insecticides to the late evening or very early morning, when bees are not foraging, lessens the possibility of causing injury to honey bees and other pollinating insects.
- Insecticides should not be applied to crops in bloom. Bees are now kept so commonly in the prairie provinces that almost every blooming field is likely to have honey bees actively foraging in the area.
- Should spraying be imminent and the movement of colonies impractical, bees may be confined to the hive for a few hours to minimize contact with the pesticide. However, care must be taken to prevent overheating of the colony during periods of confinement. Screened colonies can be assisted with cooling by supplying water-filled combs and by covering the hive with wet burlap and keeping it wet. Strong colonies during warm days should not be confined for more than a few hours. Length of confinement will depend on the residual toxicity of the pesticide in use.

Documenting bee kills — Pesticide kills should be reported to the apiculture office, even if litigation is not intended. These reports, if clearly documented, are very useful in determining both the severity of the pesticide poisoning situation and ways in which similar situations can be avoided in the future.

Documentation of pesticide kills is necessary, especially if the beekeeper intends to pursue compensation of losses. Symptoms of dying bees should be noted. Several handfuls of dead bees should be collected and immediately frozen. When transported, the bees should be kept frozen with dry ice, as pesticide residues break down quickly at warm temperatures. If litigation is intended, an impartial witness should be present when samples are collected. Photographs of the affected apiary will be useful. Records must be kept of the date and time of day of spraying, weather conditions at the time and two days before and after, the pest target, the crop, the pesticide, its formulation and rate of application, and the distance of the apiary from the sprayed fields.

Unless the apiary is directly sprayed or affected by spray drift, or the bees are foraging on land owned by the beekeeper which is mistakenly sprayed or affected by spray drift, it will be difficult for the beekeeper to win a court case. However, if the aerial applicator is spraying a field during daylight hours with a pesticide which the label clearly states must be applied before dawn or after dusk, or using a pesticide or formulation not registered for use on the crop in question, and does not have a special permit, the beekeeper should report the applicator to provincial licensing authorities. This is a dramatic measure, and hopefully, previous communications between all concerned parties will have resolved the potentially hazardous spraying situation. Although without the pollinating insects many growers would see much less return, still the beekeeper must depend on the good graces of the local growers for apiary sites and bee forage. Early and continued communication between beekeeper and grower will be much more effective in preventing bee losses and maintaining good will than action after the fact.

APPENDIX
Glossary of Apiculture Terms

Abdomen — Segmented posterior part of bee containing heart, honey stomach, intestines, reproductive organs and sting.

Acarapis woodi (Rennie) — Scientific name of honey bee tracheal mite, which infests tracheae of bees.

Acarine disease — A malady of adult bees caused by a mite, *Acarapis woodi*, infesting the thoracic tracheae.

Acid board — See fume board.

African bee — See *Apis mellifera scutellata.*

Afterswarms — Swarms which may leave the hive after the first or prime swarm has departed; afterswarms are also known as secondary or tertiary swarms.

Alarm odor — A chemical substance released from the vicinity of a worker bee's sting which alerts other bees to danger. Isopentyl acetate is the principal alarm odor; 2-heptanone, found in worker bee mandibular glands, is a secondary alarm odor.

Alighting board — Extending entrance to beehive on which incoming bees land.

American foulbrood (AFB) — Contagious disease of bee larvae caused by *Bacillus larvae* White.

Antennae — Slender jointed feelers, which bear certain sense organs, on heads of insects.

Anther — Part of flower that develops and contains pollen.

Apiarist — Beekeeper.

Apiary — The location and sum total of colonies, hives and other equipment assembled in one site for beekeeping operations.

Apiculture — The science and art of raising honey bees for man's economic benefit or personal enjoyment.

Apis — Genus to which honey bees belong.

Apis cerana — This species is found throughout Asia, and in certain countries it is the honey bee of commerce. It is often called the Indian bee.

Apis dorsata — Scientific name for giant bee of India; largest of all honey bees.

Apis florea — Being the smallest of the four species of honey bees, it is often called the dwarf bee. This species is found in Asia only, though it is more western in distribution than the other Asian species.

Apis mellifera — The common honey bee found throughout the western world though originally from the near-east. Humans have carried *Apis mellifera* from Europe to all continents.

Apis mellifera scutellata — The African bee. This is a race of *Apis mellifera* which has become established and is rapidly spreading throughout south and central America.

Artificial insemination — See instrumental insemination.

Bacillus larvae White — Bacterial organism causing American foulbrood.

Balling a queen — An attack on a queen by a number of worker bees intent on killing her by pulling at her legs and wings, stinging and suffocation. In this process the bees form a small cluster or tight ball of bees around the queen.

Bee blower — A blower driven with a gasoline engine used to remove bees from full supers of honey.

Bee bread — Stored pollen in comb.

Bee brush — A brush or whisk broom used for removing bees from combs.

Bee dance — Movement of bee on comb as means of communication; usually same movement is repeated over and over.

Bee escape — Device to let bees pass in only one direction; usually inserted between supers of honey and brood nest when removal of bees from honey is desired.

Bee glue — See propolis.

Bee gloves — Long gloves made of cloth or leather to protect the hands and wrists from stings.

Bee gum — A hollow log used for housing a colony of bees.

Beehive — Domicile for colony of honey bees.

Bee house — A house constructed to maintain colonies of bees, usually in rows along the side with openings to the outside.

Beekeeper, commercial — A beekeeper managing 200 or more hives, as a main or sole source of livelihood. He or she generally sells his or her crop in bulk. Operations of over 400 hives generally require additional help.

Beekeeper, hobby — A beekeeper tending up to 100 hives, generally to fulfill an interest and to have some honey to sell privately or to give to friends as gifts.

Beekeeper, sideline — A beekeeper tending 50-200 hives, generally to fulfill an interest and to supplement his or her main income.

Beekeeper, small commercial — A beekeeper managing 200-400 hives as his or her main source of income. Another source of income is generally required. In this size of operation the entire crop may be packed in small containers for sale or part or all of the crop may be sold in bulk.

Bee louse — Relatively harmless insect found in colonies. Larvae can damage honeycomb. Scientific name is *Braula coeca* Nitzsch.

Bee paralysis — Condition of adult bees, caused by a virus, that prevents them from flying or performing other functions normally.

Bee plants — Plant species visited by bees for nectar or pollen.

Bee space — The natural space found between combs built by bees. This space is big enough to permit free passage of bees. It measures 5 to 9 mm. Spaces larger than bee space will be filled by bees with burr and some comb or full honey comb. Spaces less than bee space will be sealed by bees with propolis. Langstroth applied this observation to North American hive equipment construction.

Beeswax — A complex mixture of organic compounds secreted by four pairs of glands on the underside of the worker bee's abdomen and used by bees for building comb. Its melting point is from 62°C - 64°C (143.6°F to 147.2°F).

Bee tree — A hollow tree occupied by a colony of bees.

Bee veil — Screen or net worn over head and neck for protection from bee stings.

Bee venom — Poison injected through bee sting.

Bee yard — See apiary.

Beeway section — Comb honey sections with a built-in beeway or bee space.

Benzaldehyde pad — A rectangular frame the size of a standard super covered with cloth (such as felt) on which is placed benzaldehyde or some other bee repellent. It is used for driving bees out of a hive or part of a hive as in removing supers full of honey. Also see Fume Board.

Bottom board — Floor of beehive.

Brace comb — Small pieces of comb made as connecting links between combs or between a comb and the hive itself. See burr comb.

Braula coeca — The scientific name of a wingless fly known as bee louse. It is of little economic importance. See bee louse.

Breathing pores — See spiracles.

Brood — Immature or developing stages of bees; includes eggs, larvae and pupae.

Brood chamber — The part of a hive where the brood is reared and food is stored. May include one or more hive bodies and the combs within.

Brood comb — Wax comb from brood chamber of hive containing brood. Usually a dark color.

Brood food — Secretion of highly nutritious food, used to feed young larvae and queens, produced in the hypopharyngeal glands in the heads of adult bees.

Brood nest — Area of hive where bees are densely clustered and brood is reared.

Brood-rearing — The raising of young bees from eggs to larvae to pupae to young adult stage.

Build-up — The natural increase in population of honey bees within a colony, from the spring cluster until the peak population is reached at the commencement of the main nectar flow.

Bulk comb honey — Comb honey produced in shallow frames and usually sold as a complete unit in the frame. See chunk comb honey.

Burr comb — Comb built out from wood frame or comb, but usually unattached on one end because the space exceeds "bee space".

Candy — See queen cage candy.

Cap — Covering of cell.

Capped brood — Brood whose cells have been sealed by the bees with a porous cover to isolate the immature bees within, during their nonfeeding prepupal and pupal periods.

Capped honey — Honey stored in sealed cells.

Cappings melter — Various types of melters used to liquefy the wax from cappings.

Cappings — The thin wax covering of cells full of honey, also, the same, after having been sliced from the surface of a honey filled comb before extracting the honey.

Carniolan bee — Gentle grayish-black bee originally from Caucasus area.

Carbolic pad or cover — A covered frame lined with cloth (such as felt) on which a solution of pure carbolic acid or phenol is sprinkled. It is used for driving bees out of a hive or part of a hive, as in removing supers full of honey. Also see fume board.

Castes — The three forms of bees; workers, drones and a queen comprising the adult population of a honey bee colony. See worker, drone, and queen.

Caucasian bee — A variety of honey bee *Apis mellifera* originating in the Caucasus mountains; noted for its heavy propolizing characteristic.

Cell — Single unit of space in comb in which honey is stored or a bee can be raised; worker cells are about 4 cells per square cm (25 cells per square inch) of comb, drone cells are about 2½ cells per square cm (18 per square inch).

Cell cup — An artificial queen cell base made of beeswax for rearing queen bees.

Chilled brood — Immature bees that have died from being too cold, frequently because of mismanagement.

Chunk comb honey — Type of honey pack in which piece of honey comb is placed in container of liquified honey or wrapped "dry" in plastic container.

Clarified honey — Honey that has been heated, then filtered to remove all wax or other particles.

Cleansing flight — Flight bees take after confinement, during which they would void their feces outside of the hive.

Clipped queen — Queen whose wing (or wings) has been clipped for identification purposes or swarm control.

Cluster — The form or arrangement of bees within a hive when ambient temperature drops below 14°C (57°F).

Colony — An aggregate of several thousand worker bees, drones and a queen bee living together in a hive or in any other dwelling as one social unit.

Comb — A back-to-back arrangement of two series of hexagonal wax cells which hold eggs, brood, pollen or honey.

Comb foundation — Manufactured sheets of beeswax with the foundation of worker cells embossed into the wax.

Comb honey — Honey in the comb usually produced in small wooden or plastic sections.

Compound eyes — The two large lateral eyes of the adult honey bee composed of many visual elements called ommatidia.

Cross-pollination — Transfer of pollen from anther of one plant to stigma of different plant of same species.

Cyanogas — A commercial preparation of calcium cyanide used to kill bees which are diseased or a nuisance in buildings and other undesirable places. it forms hydrogen cyanide gas on contact with moist atmosphere. It is a very poisonous material and must be handled with care. The gas is lighter than air.

Deep super — A super used to hold standard, full-depth frames; the usual depth is 241 mm or 244 mm (9½" or 9⅝").

Demaree — The beekeeper who invented a popular method of swarm control; also used as a verb "to demaree", in describing this method. It consists of separating the queen from most of the brood.

Dextrose — Also known as glucose; one of the principal sugars of honey. Also found in nectar.

Diastase — Enzyme that aids in converting starch to sugar. The diastase level is used as an index of the heating history of a honey.

Dividing — Separating a colony to form two or more units.

Division board — A thin vertical board of the same length and height as the inside of a super. it is used to reduce the size of the chamber or to vertically divide the hive into two parts.

Division board feeder — A wooden compartment or trough which is hung in a hive in place of a frame and contains a solution of syrup to feed bees.

Drawn combs — Combs having the cells built out by honey bees from a sheet of beeswax or plastic foundation.

Drifting — The tendency of bees to transfer to colonies other than their own because of a lack of visual cues to orient them to their "home" hive.

Drone — Male bee.

Drone brood — The male brood that is reared in larger cells than worker brood.

Drone comb — Wax comb with about 2½ cells per square cm (18 per square inch). Combs with a high proportion of drone cells are not recommended in the brood chamber.

Drone layer — A queen which lays only unfertilized eggs which result in drones because she no longer has any sperm, was poorly mated or was not mated at all.

Dwindling — Rapid or unusual depletion of hive population.

Dyce process — A patented process involving pasteurization and controlled granulation to produce a finely granulated honey product which spreads easily at room temperature.

Dysentery — A condition of adult bees resulting from an accumulation of feces within the gut. It usually occurs during winter and is caused by unfavorable wintering conditions and low quality food. Dysentery is detected by fecal spotting around the entrance and within the hive. Often associated with nosema disease.

Embed — To force wire into comb foundation by heat, pressure, or both for the purpose of strengthening the comb.

Emerging brood — Young bees first coming out of their cells.

Entrance blocks — Pieces of wood used in regulating the size of hive entrances.

Escape board — A board having one or more bee escapes in it and used to remove bees from supers above the bee escape.

Ethylene oxide — A fumigant gas mixed with CO_2 that has been used to control American foulbrood.

European foulbrood — A brood disease of bees caused by *Streptococcus pluton*.

Excluder — See queen excluder.

Extractor — A machine that rotates honeycombs at sufficient speed to remove honey from the cells by centrifugal force.

Feces — Excreta of bees.

Fermentation — A chemical breakdown of sugar caused by yeasts; in honey, fermentation is caused by the genus *Zygosaccharomyces*.

Fertile queen — A queen which has been inseminated artificially or naturally with drone spermatozoa and is capable of laying fertilized eggs.

Field bees — Worker bees which are usually 21 or more days old and work in the field to collect nectar, pollen, water and propolis.

Flash heater — Device for heating and cooling the honey within a few minutes.

Foundation — See comb foundation.

Frame — Four pieces of wood designed to hold honey comb. It consists of one top bar, one bottom bar and two end bars.

Fructose — A simple sugar, usually the predominant one in honey. Also found in nectar. [See levulose].

Fume board — A board the length and width of a super with a 3-4 cm rim and a lining of absorbent cloth, on which is placed one of several bee repellents. The fume board is then placed on the bee hive and the bee repellent drives the bees out of the honey super.

Fumidil-B — A trade name for fumagillin, the antibiotic for controlling nosema disease.

Galleria mellonella (L.) — Scientific name of greater wax moth.

Glucose — see dextrose.

Grafting — A process of removing a worker larva from its cell and transferring it to an artificial queen cup to have it reared into a queen by bees.

Granulated honey — Crystallized honey.

Green honey — Unripe honey.

Hive — Man-constructed home for bees.

Hive body — A wooden box which encloses the frames.

Hive stand — A structure that supports the hive.

Hive tool — A metal device used to open hives, pry frames apart, clean the hive, etc.

Hoffman frame — Frames with end bars widened at the top to act as a spacing device.

Honey bee — The common name for *Apis mellifera*. Correctly spelled as two words, though some bee journals and texts cling to the spelling of honey bee as one word. Order Hymenoptera, Family Apidae.

Honeydew — Sweet secretions from aphids and scale insects.

Honey flow — See nectar flow.

Honey gate — A faucet used for removing honey from tanks.

Honey house — A building used for extracting honey packaging honey, storing supers, etc.

Honey pump — Pump for transferring liquid from one container to another.

Honey stomach (honey sac) — The part of the bee's digestive tract adapted to carrying nectar, honey or water, located in the front part of the abdomen.

Honey sump — See sump.

Hormone — Substance produced in small quantity in one part of body (usually in gland of internal secretion) and transported to other parts, where it exerts its action.

Hymenoptera — An order of insects to which all bees belong, as well as ants, wasps and sawflies.

Increase — To add to the number of colonies, usually by dividing those already on hand.

Inner cover — A lightweight cover used under a standard telescoping cover on a bee hive.

Instrumental insemination — The introduction of drone spermatozoa into the genital organs of a virgin queen by means of special instruments.

Invertase — An enzyme produced by honey bees that speeds inversion of sucrose to glucose and fructose.

Isle of Wight disease — An early and little used name for acarine disease.

Italian bees — Bees originating from Italy; most popular race in North America.

Langstroth frame — A frame measuring 45 cm long by 23 cm deep (17⅝" x 9⅛"), exclusive of the lugs or shoulders that support the frame.

Langstroth hive — Hive with movable frames. Dimensions such that the beespace is allowed between surfaces.

Larva — The second stage in the complete development of an insect, such as the honey bee, having complete metamorphosis or four stages — egg, larva, pupa, adult. The plural of the term is larvae.

Laying worker — A worker bee that lays eggs which develop into drones. Laying workers usually develop in colonies that have been queenless for a long period.

Legume — One of the family Leguminosae, which includes clover, alfalfa, peas and beans.

Levulose — Fructose or fruit sugar; one of the sugars, with glucose, into which sucrose is changed.

Mandibles — The jaws of an insect. In the honey bee and most insects the mandibles move in a horizontal rather than in a vertical plane.

Manipulation of colonies — Using hive equipment to best advantage in aiding colony development.

Mating flight — The flight taken by a virgin queen during which time she mates in the air with one or more drones. Normally queens mate six to eight times during one or more mating flights.

Mead — Another name for honey wine.

Metamorphosis — Changes of insect from egg to adult.

Migratory beekeeping — The moving of colonies of bees from one locality to another during a single season so that advantage can be taken of two or more nectar flows or different crops.

Movable frame — A frame or comb constructed on the principle of the "bee space". When placed in a hive it remains unattached to its surroundings by pieces of burr comb or heavy deposits of propolis, and is therefore, easily removed for inspection.

Nectar — A sweet carbohydrate exudation secreted by glands or nectaries in different parts of plants, chiefly in the flowers. The raw source of honey. See nectaries. See sucrose.

Nectaries — Plant glands which secrete nectar.

Nectar flow — The production of nectar by various plant species sufficient that bees gather and store the nectar and convert it to honey.

No Ceema Fix — A trade name for fumagillin, used to control nosema disease.

Nosema disease — Disease of adult bees caused by protozoan spore-forming mid-gut parasite, *Nosema apis Zander.*

Nucleus — A small colony of bees often used in queen-rearing or mating.

Nurse bees — Young worker bees that feed larvae.

Observation hive — A hive made with glass sides to permit observation of the bees at work.

Ocellus — A simple eye with a single lens. The honey bee has three ocelli on the top of its head.

Ommatidium — One of the visual units comprising the compound eye.

Out apiary — An apiary kept at a distance from the home or honey house of the beekeeper.

Overstocking — A condition reached when there are too many colonies of bees for a given locality.

Package bees — Two or three pounds of bees which are shaken from combs of beehives into wire mesh cages. Into each package is placed a caged, mated queen. Packages are usually produced from colonies in the southern United States and California in early spring and shipped to northern beekeepers for the purpose of establishing honey bee colonies.

Paralysis — See bee paralysis.

Parthenogenesis — The development of young from unfertilized eggs. In honey bees the unfertilized eggs produce only drones.

Pfund grader — A device used to give a numerical value to honey color.

Pheromone — A chemical secretion released externally by one animal which stimulates a response in a second animal of the same species.

Piping — A series of sounds made by queens.

Pistil — Female part of flower consisting of stigma, style and ovary.

Play flights — Short orientation flights taken by young bees in front of the hive and in its vicinity to acquaint the young bees with their immediate surroundings. These are sometimes mistaken for robbing or preparation for swarming because they may involve large numbers of bees at one time, usually during the warm part of day.

Pollen — The male sex cells of plants gathered by worker bees from the anthers of flowers. Pollen provides protein, minerals, fats and vitamins which are consumed by the young nurse bees and elaborated into brood food or "royal jelly".

Pollen basket (corbiculum) — A flattened concave depression surrounded by curved spines, located on the outside of the tibiae of the bee's hind legs, and adapted for carrying the pollen gathered from flowers to the hive. The mass of pollen within each corbiculum is referred to as a pollen pellet.

Pollen insert — A device inserted into the entrance of a colony into which hand collected pollen is placed. As the bees leave the hive and pass through the trap, some of the pollen adheres to their bodies and is carried to the blossoms, resulting in cross-pollination.

Pollen substitute — A food material which is used to substitute wholly for pollen to supply the needed protein, vitamins and fats to a bee's diet. It includes water, sugar and other materials such as soy flour, brewer's yeast, and egg yolk.

Pollen supplement — A mixture of pollen and other protein sources along with sugar and water, fed to colonies to supplement their protein needs.

Pollen trap — Device installed over colony entrance that scrapes and accumulates pollen from the pollen baskets on the hind legs of bees returning to their hives.

Pollination — The transfer of pollen from the anthers (male) to the stigma (female) of flowers.

Prime swarm — The first swarm to issue, usually with the old queen, from the parent colony.

Proboscis — Tongue of bees, and other insects.

Propolis — Resins and gums gathered from trees and used by bees in sealing cracks, repairing cells, and covering objectionable material within the hive. Also referred to as bee glue.

Pupa — Third stage in the development of an insect having complete metamorphasis. In this stage the organs of the larva are replaced by those which will be used as an adult. See larva.

Queen — Sexually developed female bee, larger and longer than worker bee.

Queen banks — Colonies in which caged queens are placed for storage until use.

Queen cage — A small cage in which a queen and five or six worker bees may be confined for shipping and/or introduction into a colony. May or may not contain candy.

Queen cage candy — Candy made by kneading powdered sugar with invert sugar syrup until it forms a stiff dough; used in queen cages.

Queen cell — A special elongated cell resembling a peanut shell in which the queen is reared. It is usually an inch or more in length. The inside diameter is about 8 mm. It hangs down from the comb in a vertical position.

Queen cup — A cup-shaped cell which hangs vertically in a hive. It is made of beeswax or plastic and may become a queen cell if an egg is placed in it and if bees add wax to it. See Queen cell.

Queen excluder — A device made of wire, or wood and wire or zinc, having openings of about 5 mm which permit workers to pass through but exclude queen and drones. It is used to confine the queen to a specific part of the hive, usually the brood chamber.

Queenless — Without a queen.

Queen mailing cages — Cages 8 x 3 x 2 cm in which a mated queen with 6 to 10 attendant workers and a soft candy for food are placed for the purpose of travel through the mail.

Queen mating nuclei — Small colonies in which unhatched queen cells are placed and from which virgin queens will make mating flights.

Queen-rearing colonies — Colonies managed in such a way as to produce queen cells.

Queenright — With a queen.

Queen substance — Material produced from glands in head of queen; has strong effect on colony behavior and the sexual development of worker bees, and is also a sex attractant during queen mating flights.

Rendering wax — The process of melting combs and cappings and refining the wax.

Ripe honey — Honey from which bees have evaporated sufficient moisture so that it contains no more than 17.8 per cent water.

Robbing bees — Bees which enter colonies other than their own in order to remove honey and carry it to their own hive. This usually occurs in early spring and fall.

Robbing — Applied to bees stealing honey from other colonies, cappings, recently extracted honey supers, etc.

Royal jelly — A highly nutritious glandular secretion of young adult bees; it is used to feed the queen and the young brood.

Sacbrood — Minor disease of bees caused by filterable virus.

Sealed brood — Brood in late larval and pupal stages with cells sealed. See capped brood.

Self-spacing frames — Frames made with a spacing device so that when they are pushed together they stand a bee space apart. See Hoffman frame.

Self-pollination — Transfer of pollen to stigma within the same flower or to a different flower of the same plant.

Septicemia — Usually minor disease of adult bees caused by *Pseudomonas apiseptica* (Burnside).

Scent gland — Nasanov gland of worker honey bees located dorsally between sixth and seventh segments of abdomen.

Sex attractant — A chemical substance which attracts an animal of the same species, male or female, for the purpose of mating. The sex attractant in *Apis mellifera* is 9-oxodec-trans-2enoic acid.

Shaking — The process of placing bees from parent colonies into packages.

Shallow super — Any one of several super depth sizes less than the depth of a standard super. Commonly, shallow supers vary from 11 to 18 cm (4-7") in depth.

Skep — A bushel basket made of coiled straw or wicker, once used to carry agricultural produce and later specialized and used in the inverted position as a domicile for honey bees. Since individual combs are not readily movable for disease inspection their use is illegal in North America.

Slumgum — The refuse from melted comb and cappings after the wax has been rendered or removed.

Smoker — Device used to produce and blow smoke on bees to help in calming bees.

Solar wax extractor — Glass-covered box in which wax combs are melted by sun's rays and wax is recovered in cake form.

Spermatheca — A small sac connected with the vagina of the queen in which are stored the spermatozoa received in mating with drones.

Spiracles — Openings in the body wall through which the bee breathes: external openings of tracheae.

Stamen — Male part of flower on which pollen-producing anthers are borne.

Stigma — Receptive part of pistil where pollen germinates.

Sting — Modified ovipositor of female Hymenoptera developed into organ of defense.

Sucrose — Cane sugar: also one of the sugars in nectar.

Sump — Temporary holding area for honey between extractor and tank.

Supers — A hive box or hive bodies with or without frames.

Supersedure — Replacement of the existing queen by a young queen produced by the bees within the colony from their own larvae or eggs.

Surplus honey — The honey which is removed from the hive and which is over and above that which bees need for their own use.

Swarm — The aggregate of worker bees, drones and a queen that leaves the mother colony to establish a new colony. Swarming is the division and dispersal of honey bee colonies.

Terramycin — A trade name for oxytetracycline, a drug commonly used to prevent European and American foulbrood.

Thorax — The middle region of the bee's body that carries the wings and legs.

Tracheae — The breathing tubes within an insect opening externally via the spiracles.

Tropilaelaps clareae — One of few parasitic mites associated with honey bees. So far known only in Asia.

Uncapping — The process of removing the waxed cappings from cells containing honey.

Uncapping knife — A knife used to shave or remove the beeswax cappings or honey cell caps from combs of sealed honey preparatory to extraction. The knives are usually heated by steam or electricity.

Unite — Combine one colony with another.

Unsealed brood — Brood in egg and larval stages only.

Varroa jacobsoni — One of four parasitic mites associated with honey bees. A recent pest of *Apis mellifera* in South America.

Ventriculus — The stomach of the bee located in the abdomen between the honey stomach and the small intestine.

Virgin queen — Unmated queen.

Wax glands — The eight glands that secrete beeswax. They are located in pairs on the last 4 visible ventral abdominal segments.

Wax moth — Lepidopterous insect whose larvae destroy wax combs.

Wax press — An appliance used in rendering bees wax.

Wild bees — Solitary or sub-social bees other than honey bees of the genus Apis. The term is sometimes used to refer to a nest of honey bees in a tree or wall of a building.

Windbreaks — Specially constructed fences or natural barriers to reduce the force of the wind in an apiary.

Wired foundation — Foundation with strengthening wires embedded in it.

Wired frames — Frames with wires holding sheets of foundation in place.

Worker bee — A female bee whose organs of reproduction are only partially developed and which is responsible for carrying on all the routine work of the colony.

Worker comb — Honeycomb with about 4 cells/cm^2 (25 cells per square inch).

ADDITIONAL REFERENCES

Books

ABC and XYZ of bee culture. 1974. ed. A.I. Root Co., Medina, Ohio.

Frisch, K. von. 1967. The dance language and orientation of bees. Oxford University Press, London.

The hive and the honey bee. 1975. ed. Dadant and Sons, Hamilton, Illinois.

Honey 1975.ed. Eva Crane. William Heinemann Ltd., London.

Honey bee pests, predators, and diseases. 1978. ed. Roger A. Morse. Cornell University Press, Ithaca, N.Y.

Johansson, T.S.K. and M.P. Johnasson. 1978. Some important operations in bee management. International Bee Research Association, London.

Laidlaw, H.H., JR. 1979. Contemporary queen rearing. Dadant and Sons, Hamilton, Illinois.

Laidlaw, H.H., JR. and J.E. Eckert 1962. Queen rearing. University of California Press, Berkeley, CA.

Periodicals

Canadian Beekeeping. Orono, Ontario. L0B 1M0.

American Bee Journal. Dadant and Sons, Hamilton, ILL. 62341.

Gleanings in Bee Culture. A.I. Root Co., Box 706. Medina, Ohio. 44258-0706.

Bee World. International Bee Research Association, London.

Speedy Bee. Box 998, Jesup Georgia 31545.

Pamphlets

Pamphlets pertaining to various aspects of beekeeping are available from the provincial apiculture office.

APICULTURE AND RELATED PERSONNEL IN ALBERTA

Provincial Apiculturist, Alberta Agriculture, Box 415, Falher, Alberta T0H 1M0. Telephone (collect) 837-2252

Douglas Colter, Chief Apiary Inspector, Alberta Agriculture, Box 415, Falher, Alberta T0H 1M0. Telephone (collect) 837-2252

Michael Dolinski, Section Head, Entomology, Plant Pathology and Apiculture, Alberta Agriculture, 7000 - 113 Street Edmonton, Alberta T6H 5T6. Telephone 427-5339, rite number 147-5339.

Agriculture Canada, Food Production and Inspection Branch, Dairy, Fruit and Vegetable Division, 9820 - 107 Street, Edmonton, Alberta. Telephone 420-2800.

Alberta Beekeepers Association, Secretary-Treasurer, #24, 7215 - 147 Avenue, Edmonton, Alberta T5C 2T1. Telephone 475-3314

Beaverlodge and District Beekeepers Association
Calgary and District Beekeepers Association
Edmonton and District Beekeepers Association
Peace River and District Beekeepers Association
Red Deer and District Beekeepers Association

For information regarding the local beekeepers associations, please contact the provincial apiculturist.

APICULTURE AND RELATED PERSONNEL IN SASKATCHEWAN

John Gruszka, Provincial Apiculturist, Saskatchewan Agriculture, Box 3003, Prince Albert, Saskatchewan S6V 6G1. Telephone (306) 953-2770.

Dorothy Murrell, Apiculture Specialist, Saskatchewan Agriculture, Box 3003, Prince Albert, Saskatchewan S6V 6G1. Telephone (306) 953-2770.

Lloyd Harris, Provincial Entomologist, Saskatchewan Agriculture, 3085 Albert Street, Regina, Saskatchewan S4S 0B1. Telephone (306) 787-4669.

Agriculture Canada Food Production and Inspection Branch, Dairy, Fruit and Vegetable Division, Box 8060, Regina, Saskatchewan S4P 4E3. Telephone 780-5172, 780-5004 or 1420 - 606 Spadina Crescent East, Saskatoon S7K 3H1. Telephone 975-4084, 975-4147.

Saskatchewan Beekeepers Association, Box 3003, Prince Albert, Saskatchewan S6V 6G1. Telephone (306) 953-2770.

Saskatoon Bee Club

Regina Bee Club

Weyburn Bee Club

Swift Current Bee Club

APICULTURE AND RELATED PERSONNEL IN MANITOBA

Don Dixon, Provincial Apiarist,Manitoba Agriculture,911 - 401 York Avenue,Winnipeg, Manitoba R3C 0P8. Telephone: 945-3861.

Barry Fingler,Extension Apiarist,Manitoba Agriculture,911 - 401 York Avenue,Winnipeg, Manitoba R3C 0P8. Telephone: 945-4825.

S. Cameron Jay,Professor and Head,Department of Entomology,University of Manitoba,Winnipeg, Manitoba R3T 2N2. Telephone: 474-6020.

Agriculture Canada,Food Production and Inspection Branch,Fruit and Vegetable Division,Room 602 - 269 Main Street,Winnipeg, Manitoba R3C 1B2. Telephone: 949-2222.

Manitoba Beekeepers' Association,911 - 401 York Avenue,Winnipeg, Manitoba R3C 0P8.Telephone: 945-3861.

Regional Beekeeper Associations

Brandon Area Beekeepers' Association

Red River Apiarists' Association (Winnipeg)

Southeast Beekeepers' Association

CANADA HONEY GRADING REGULATIONS

Excerpts from the Canada Agricultural Products Standards Act, Honey Regulations, pertaining to grading honey.

Section 8

Honey may be classified as to colour and graded under these Regulations only if

(a) it is the food derived from the nectar of blossoms or from secretions of or on the living parts of plants by the work of honey bees;

(b) it has a consistency that is fluid, viscous or partly or wholly crystallized;

(c) its composition meets the requirements set out in Table IV of Schedule 1 for a kind of honey specified therein;

(d) it has

  (i) a diastase activity, determined after processing and blending, as represented by a diastase figure on the Gothe scale of not less than 8 where the hydroxymethylfurfural content is not more than 40 mg/kg. or

  (ii) a diastase activity, determined after processing and blending, as represented by a diastase figure on the Gothe scale of not less than 3 where the hydroxymethylfurfural content is not more than 15 mg/kg;

(e) it is clean, wholesome and fit for human consumption; and

(f) it has not, in the opinion of the Minister, any deterioration seriously affecting its edibility, appearance or shipping quality.

TABLE III

Grades of Honey

1. "Canada No. 1" is the grade name of honey that, in addition to meeting the requirements as set out in section 8,

  (a) contains not more than 17.8 per cent moisture or, where its container is marked "pasteurized" or "pasteurisé", not more than 18.6 percent moisture;

(b) is free from any foreign material that would be retained on a U.S. National Bureau of Standards standard 80-mesh screen;

(c) contains not more than 0.1 percent water insoluble solids or, where its containers is marked "pressed" or "de presse", not more than 0.5 percent water insoluble solids;

(d) has a flavour characteristic of its colour classification and is free from any objectionable flavour, aroma or taint;

(e) where its container is marked "liquid" or "liquide", is clear, bright, uniform in colour and free from visible crystals; and

(f) where its container is marked "creamed" or en cremè" or is otherwise marked to indicate that the contents are granulated, has a smooth fine texture and complete and uniform granulation.

2. "Canada No. 2" is the grade name of honey that, in addition to meeting the requirements set out in section 8,

(a) contains not more than 18.6 percent moisture or, where its container is marked "pasteurized" or "pasteurisé", not more than 20 percent moisture;

(b) is free from any foreign material that would be retained on a U.S. National Bureau of Standards standard 60-mesh screen;

(c) contains not more than 0.1 percent water insoluble solids or, where its containers is marked "pressed" or "de presse", not more than 0.5 percent water insoluble solids:

(d) has a flavour that may be slightly off but its honey flavour is not substantially impaired;

(e) where its container is marked "liquid" or "liquide", has a colour that may be dull and cloudy or turbid or slightly uneven and shows not more than slight signs of crystalization in the form of a light suspension or minor sedimentation of crystals; and

(f) where its container is marked "creamed" or en crème" or is otherwise marked to indicate that the contents are granulated, has a texture that may be medium coarse or gritty, but not extremely coarse or gritty, and has a complete and fairly uniform granulation.

3. "Canada No. 3" is the grade name of honey that, in addition to meeting the requirements set out in section 8,

(a) contains not more than 20 percent moisture;

(b) contains not more than 0.1 percent water insoluble solids or, where its containers is marked "pressed" or "de presse", not more than 0.5 per cent water insoluble solids;

(c) has a flavour that may be slightly off but its honey flavour is not substantially impaired.

SCHEDULE 1

(ss. 2, 5, 6, 8, 35 and 36)

TABLE 1

"Prepackaged Honey"

Class	**Designation on Honey Classifier**	**"Reading on Pfund Honey Grader"**
1. "White"	not darker than White	not more than 30 millimetres
2. "Golden"	darker than White but not darker than Golden	more than 30 millimetres but not more than 50 millimetres
3. "Amber"	darker than Golden but not darker than Amber	more than 50 millimetres but not more than 85 millimetres
4. "Dark"	darker than Amber	more than 85 millimetres

TABLE 2

Honey Packed in Bulk Containers

Class	**Designation on Honey Classifier**	**"Reading on Pfund Honey Grader"**
1. "Extra White"	not darker than Extra White	not more than 13 millimetres
2. "White"	darker than Extra White but not darker than White	more than 13 millimetres but not more than 30 millimetres
3. "Golden"	darker than White but not darker than Golden	more than 30 millimetres but not more than 50 millimetres
4. "Light Amber"	darker than Golden but not darker than Amber	more than 50 millimetres but not more than 85 millimetres
5. "Dark Amber"	darker than Amber but not darker than Dark	more than 85 millimetres but not more than 114 millimetres
6. "Dark"	darker than Dark	more than 114 millimetres

TABLE IV

Composition of Certain Kinds of Honey

Column I	**Column II**	**Column III**	**Column IV**
Composition of Honey	**Honeydew Honey**	**Lavender, Ruginia, Alfalfa or Banksia Menziesii Honey**	**Blossom Honey other than the kinds named in Column III**
1. Apparent reducing sugar calculated as invert sugar	not less than 60 per cent	not less than 65 per cent	not less than 65 per cent
2. Moisture	not more than 20 per cent	not more than 20 per cent	not more than 20 per cent
3. Apparent sucrose	not more than 10 per cent	not more than 10 per cent	not more than 5 per cent
4. Water-insoluble solids	(a) not more than 0.1 per cent, where not pressed (b) not more than 0.5 per cent, where pressed	(a) not more than 0.1 per cent, where not pressed (b) not more than 0.5 per cent, where pressed	(a) not more than 0.1 per cent, where not pressed (b) not more than 0.5 per cent, where pressed
5. Ash	not more than 1 per cent	not more than 0.6 per cent	not more than 0.6 per cent
6. Acid	not more than 40 milliequivalents per 1 000 grams	not more than 40 milliequivalents per 1 000 grams	not more than 40 milliequivalents per 1 000 grams

Sections 29 and 30. Container sizes for graded honey.

a. any net weight up to and including 150 g
b. 250 g
c. 375 g
d. 500 g
e. 750 g
f. 1 kg
g. 1.5 kg
h. 2 kg
i. 3 kg
j. 5 kg
k. 7 kg
l. 15 kg
m. 30 kg
n. larger containers the net weight of which is measured in multiples of 1 kg.

RECOMMENDATIONS FOR FEEDING ANTIBIOTICS

Handling and storage of antibiotics

Antibiotics are subject to degradation under heat and sunlight. Oxytetracycline and fumagillin must not be added to hot water or hot sugar syrup as they will be rendered useless. Antibiotics should be added after the solution is cool or tepid. As sunlight degrades antibiotics, they should not be fed in exposed glass jars as with boardman feeders or jars above an inner cover unprotected from sunlight.

Oxytetracycline and fumagillin should not be used after the expiry date on the package. They should be stored in moisture proof containers in a refrigerator or freezer and not be exposed to heat or sunlight.

Antibiotics should be used only at the recommended dosages for maximum effectiveness. Lower dosages will result in decreased protection while increased dosages may harm bees and brood.

Caution — All feeding of antibiotics (oxytetracycline and fumagillin) must cease three weeks prior to the main honey flow to prevent honey contamination.

Oxytetracycline

The bacteria causing both American and European foulbrood are susceptible to oxytetracycline. This drug does not kill the bacteria but acts to suppress germination and multiplication when ingested with the bacteria in the brood food.

One formulation of the antibiotic is marketed under the trade name Terramycin. All recommendations are based on Terramycin Animal Formula-25, which is a water soluble powder containing 25 g active ingredient in 400 g carrier. Other strengths and formulations can be used but the dosage must be varied according to the activity of the formulation.

Oxytetracycline can be used as a preventive treatment against American foulbrood; however, it is not recommended as a cure. Before feeding oxytetracycline, hives must be examined for signs of AFB and all infested frames removed and destroyed.

Oxytetracycline may best be administered as a dust formulation of 5 parts icing sugar: 1 part Oxytetracycline 25. One 400 g package of oxytetracycline should be mixed with 2 kg of icing sugar to dose approximately 80-100 colonies. The dust is applied at a rate of 30 mL (2 tablespoons) per colony across the ends of the top bars so as to avoid direct contact with open brood, as this can cause brood mortality. Colonies are dusted every 10 days to two weeks until 3 weeks prior to the honey flow.

Oxytetracycline may also be administered in sugar syrup at a rate of 5 mL (1 teaspoon) Terramycin Animal Formula-25 per 4.5 L (1 gallon) for overwintered and package colonies. One package (400 g) of Terramycin is sufficient for 450 L (100 gallons) sugar syrup.

It has been shown that oxytetracycline breaks down in solution and looses its effectiveness with time. Therefore medicated syrup should be used immediately and should be consumed within one week. Otherwise the dusting method should be used for spring medication.